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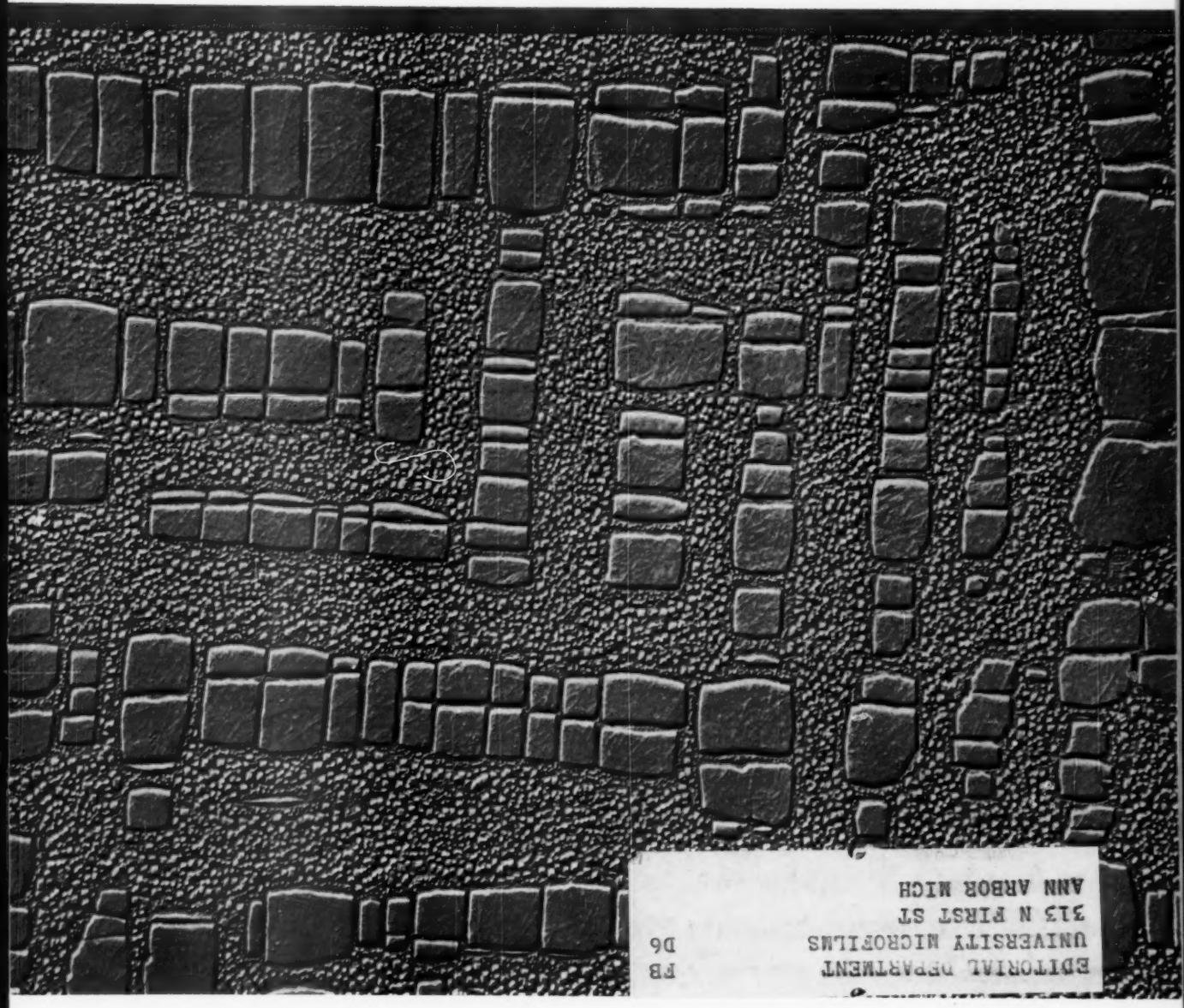

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$$\eta = \frac{\tau}{\dot{\gamma}}$$

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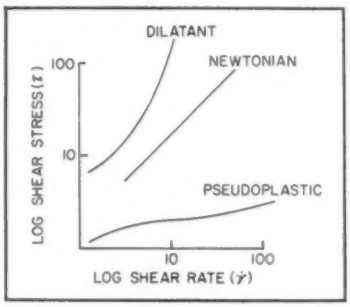

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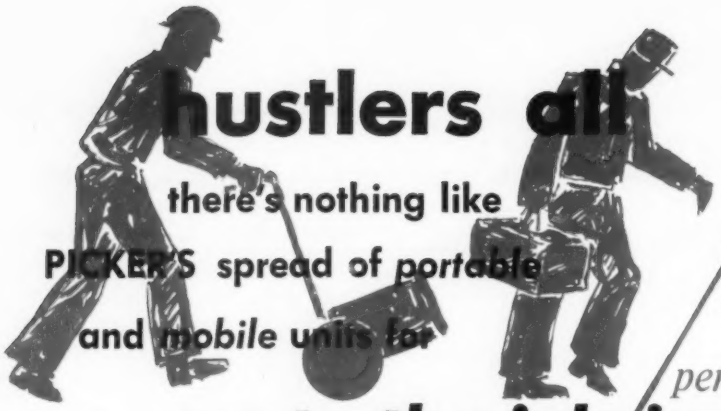

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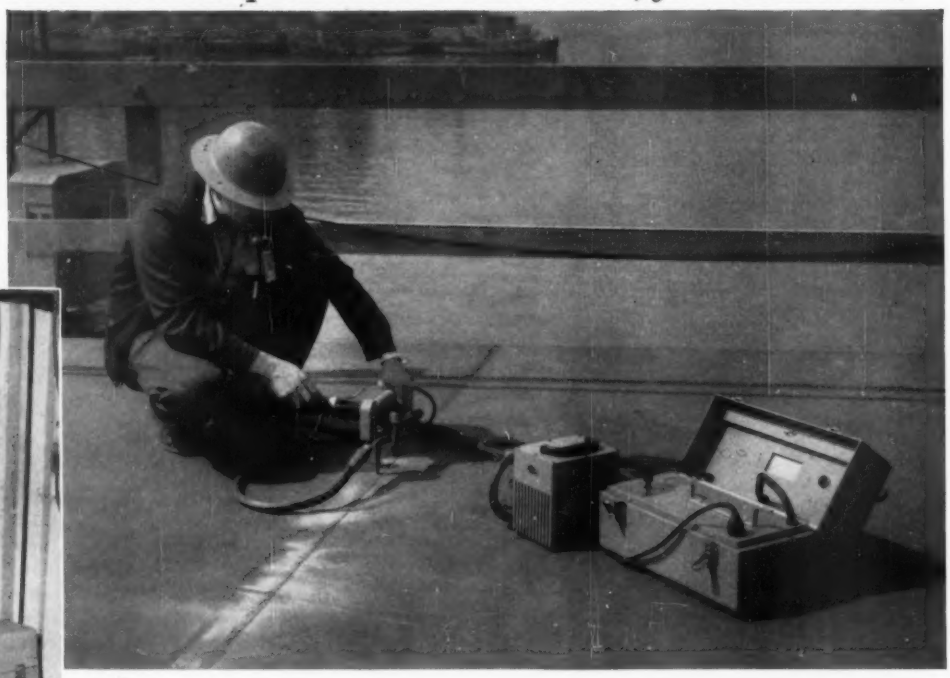

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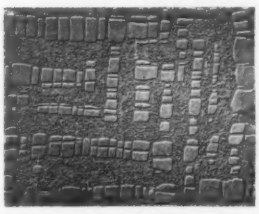
COVER PHOTO:

Ni_3Al Precipitate in a Nickel-Titanium-Aluminum Alloy

The large cube-shaped precipitate particles were formed during isothermal aging, and the small precipitate particles on cooling from the aging temperature. The unique morphology of the precipitate arises from its close structural relationship to that of the matrix. Negative collodion replica shadow-cast with chromium. Magnification 20,000×. Twelfth ASTM photographic exhibit. First Prize, Electron Micrographs—Replicas. A. S. Holik, General Electric Co., Schenectady, N. Y.



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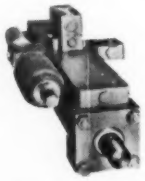

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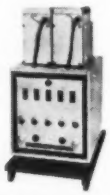

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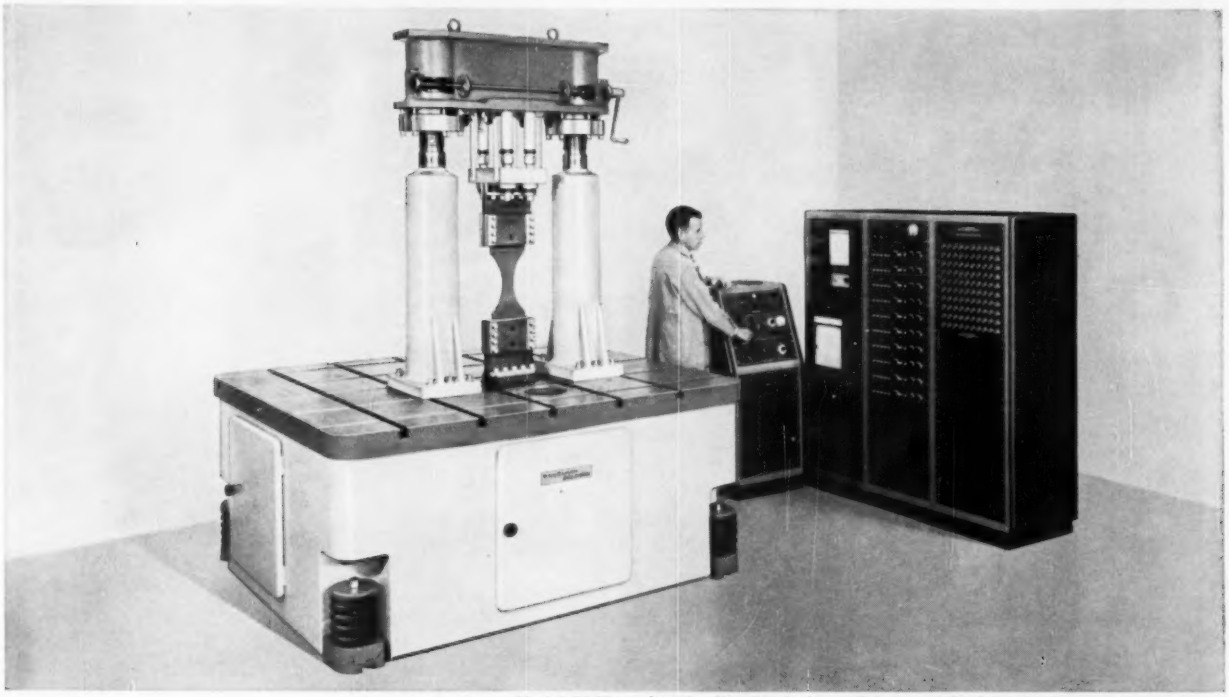

Model IV-20 equipped with direct stress fixture and Model P-10 Program Controller.

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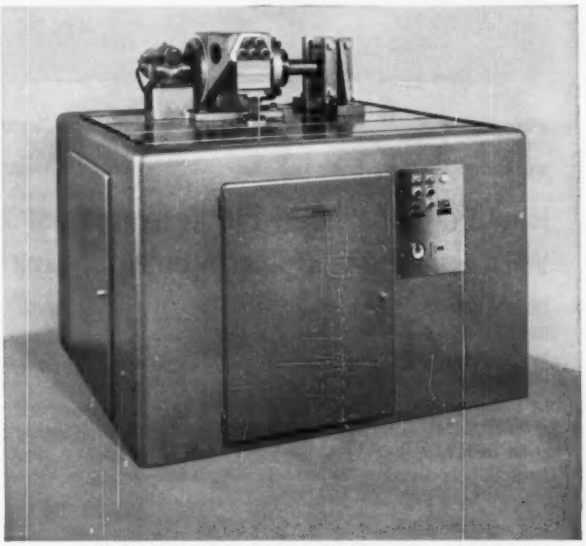

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IMPACT!

New Plas-Tech Full-Range Universal Tester Correlates With In-Service Performance for General Electric

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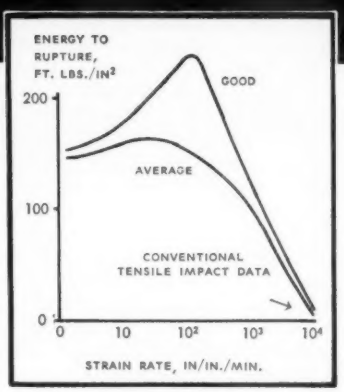

Work to rupture vs. strain rate for representative good vs. average refrigerator door liners.

Model 581B Plastechon Universal Tester

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Materials
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Volume 1, Number 10, October, 1961

JFK Rivals IBM

ON THURSDAY afternoon, Sept. 20, we attended a White House briefing conference held for some 35 members of the Society of Business Magazine Editors. If this short account of that meeting has a "gee whiz" flavor, we hasten to admit that this was the first time we had sat at a conference table with the President of the United States.

Upon arrival at the White House, we were moved quickly, noiselessly, and painlessly into the cabinet room, there to await the President. The conference table is an elongated octagon, its mahogany top liberally scarred by years of high-level emphasis. At the center of one long side, dwarfed by its upholstered, brass-studded neighbors, and looking very much like a street urchin in a row of Supreme Court Justices, sat a small wooden rocker wearing a loose green slipcover.

At about 5:30 the President entered, with Mr. Salinger. He shook a few hands and then asked those of us who could to find seats. We sat in the Labor Secretary's chair at one end of the table. President Kennedy eschewed the rocker and sat himself somewhat stiffly on one of its more patrician neighbors.

Since this was a "background" conference, the discussion was off the record. But the still-vivid mental picture of the young, vigorous, supremely confident Chief Executive is ineradicable. The impression that we had formed during the so-called television "debates" last fall—that this man has as many facts at his fingertips as we have in our reference library—was reinforced.

To one who needs a moment of reflection before he dials his own home telephone, the President appears to be an inexhaustible source of statistical and other information. Perhaps, if we could find his secret, our information retrieval problems could be solved. We could store our information in people instead of on cards, tapes, film, and other brainless objects.

Some of those present said afterward that they suspect some of this glib shower of facts is of the smokescreen variety—that the attitude, on occasion, is, "there's a number for you; if you don't like that number, have you got a better one?" Probably each of us is guilty of this to some degree, but our own impression is that here is an exceptionally knowledgeable man. We feel that President Kennedy must be credited with being, in the broad area of topics of interest to the Federal Government (and what does that exclude these days?), abundantly well-informed. In his brief opening remarks, and in his answers to the questions that followed, he spoke in specifics, not in glittering generalities. Sitting gingerly forward on his chair, his eyes focused on a point some eight inches above your head, his open right hand punctuating his remarks in that familiar chopping motion, he displayed remarkable adeptness in memory search, correlation, and readout.

To paraphrase Voltaire, one may not approve of all that he has to say, but one is forced to admire his style in saying it.

A.Q.M.

The Indirect Tension Test for Concrete*

By NEAL B. MITCHELL, Jr.

The purpose of this paper is to evaluate the indirect tension test as a standard measure of tensile strength for concrete and other brittle materials. Present and proposed tension testing procedures are compared theoretically and experimentally with the indirect tension test.

Evaluation of the various failure theories indicates that the Mohr failure theory is a satisfactory representation of the failure conditions in this test. Mathematical considerations assume elasticity to failure, and the stress conditions are evaluated for both point and distributed loads.

Test data on high-strength concrete cylinders are compared with other published results from this test and also with results of tensile strength measurements using other tests. Moisture, testing speed, plate size, plate type, and cylinder size are considered with respect to their effect on test results. Basic recommendations are advanced for this test procedure.

Indirect tension test results using Keene's cement cylinders are presented, and unique fracture characteristics are explained.

A tension test for concrete was developed about 15 years ago in Brazil (1)[1] and independently, at about the same time, in Japan (2). This test consisted of crushing cylindrical specimens by placing them horizontally between the loading surfaces of the testing machine so that the load was applied to the specimens along two opposite generatrices (Fig. 1). The specimens used for this test were the same as those used for the standard unconfined compression test.

Failure of the specimen occurs on the plane passing through the two generatrices where the load is applied (Fig. 2). Failure starts in the central part of the specimen and is not affected by surface conditions such as crazing or wall effects. This test, therefore, is free from those conditions which ordinarily cause premature failure of a test specimen.

Comparison with Other Tension Tests

There have been many attempts to try to calibrate the indirect tension test with the standard briquet and flexural beam test (3–6). The reported tests all indicated that the flexural beam test (modulus of rupture) gave higher values of observed tensile strength, and the briquet gave lower values. All found that the cylinder test had the best reproducibility of the tension tests but that calibration with other tests is open to question.

Use of the figure-eight briquet, which is the accepted tension test for mortar, is unsuitable for concrete. Even when the specimen is molded from paste, the results are questionable. The maximum stress at the central cross-section is about 1.75 times the average stress, and photoelastic studies show large stress concentrations at the loading grips. In actual tests with conglomerates, the fracture usually occurs at the weakest point between the grips and the central cross-section. Strength calculations using this testing procedure neglect these stress concentrations.

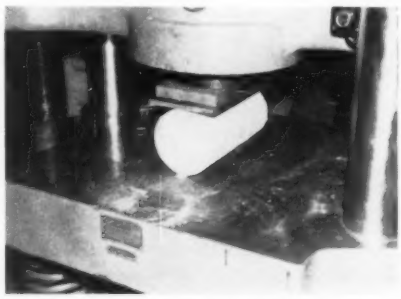


Fig. 1.—Method of Placing Concrete Specimens for Tension Test.

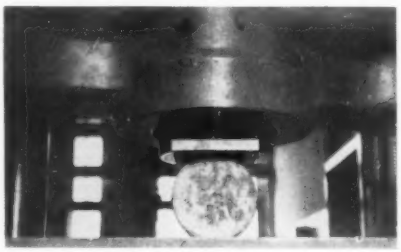


Fig. 2.—Plane of Specimen Failure in Indirect Tension Test.

These considerations indicate that the briquet tests give reported strengths below the true tensile strength of the material. Abbott and Reinschmidt (4) found that mortar cylinders tested by the indirect tension test method failed at 1.4 to 1.6 times the failure stress of the mortar briquets. Their photoelastic studies of a Lucite briquet indicated that the principal stress at the grips was 1.34 times the stress on the minimum cross section. These results give a strong indication that the indirect tension test results are a reasonable measure of tensile strength.

A second method for determining tensile strength is to find the modulus of rupture by testing beams in flexure, and then to establish a factor that relates tension to modulus of rupture. This factor is disputed, because most studies have been designed to determine a constant

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Sixty-fourth Annual Meeting of the Society, June 25–30, 1961.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

NEAL B. MITCHELL, JR., received his Sc.B. in engineering from Brown University and his M.S. in civil engineering from MIT. He has taught at Tufts University and Cornell University and is presently assistant professor in the Graduate School of Design at Harvard University. He has been engaged in research on the strength of concrete for the last four years.

conversion factor. This conversion factor seems to be a variable that decreases as the tensile strength increases.

Also the stress distribution at rupture is different from the linear distribution assumed in the formulas of strength of materials. Local disturbances, shrinkage, crazing, and stress concentrations modify the results, along with the type of center-loading used and the depth of cross-section. In fact, only statistical results of this test seem to be of any analytical value.

Tension tests with circular bobbins and cylinders with embedded studs have also been advanced as possible testing procedures. These methods not only suffer from the theoretical faults of the briquet and beam, but also require extreme skill and care in making and testing the specimens. These methods seem to be of little value as field testing procedures.

The Gonnerman and Shuman (7) tension tests of cylinders that were held in grips compare favorably with test results using the indirect tension test method. However, this test requires special test specimens with special testing grips.

Using octahedral stress theory, Bresler and Pister (8) computed a value for pure tension of a series of compression-torsion tests on hollow cylinders. For the compressive strength of concrete considered, their computed tensile strength was within the range of values that has been determined by experimental tests with the indirect tension test.

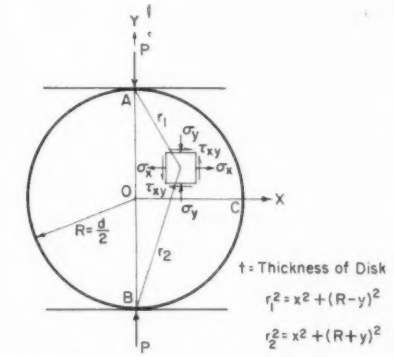
Indirect tension test results are in agreement with other more complex methods of tension testing, and they are reasonable when compared with results from the standard briquet and flexure test. Quality of results, ease of casting, ease of testing, simplicity of shape, and the relatively simple expressions that can be developed to determine the stress conditions should lead to widespread acceptance of this test.

Failure Theory Considerations

Before attempting a theoretical study of this test, the various strength theories were considered. Fracture of specimens of brittle crystalline materials, such as natural rocks or cast iron, and of certain brittle conglomerates of materials (concrete) seem to be best expressed phenomenologically by the Mohr failure theory and its extension, the octahedral shear stress theory. The maximum stress theory, often called Rankin's theory, is also satisfactory. However, the Mohr theory would seem to be the most satisfactory means of expressing the failure conditions.

The main assumption of the Mohr theory is that the intermediate principal stress has no influence on failure. Thus, according to Mohr, a material will fail either through plastic slip or by fracture when the shearing stress τ in the plane of slip has increased to a certain value (also dependent on the normal stress acting across the same plane) or when the largest tensile stress has reached a limiting value that is dependent on the properties of the material.

Consideration of the octahedral stress theory would seem necessary only when the intermediate principal stress is significant. Bresler and Pister (8) have illustrated the need for this consideration when evaluating their compression-torsion data, but Guralnick (9) has illustrated the compatibility of general test



$$\sigma_x = \frac{-2P}{\pi t}\left[\frac{(R-y)x^2}{r_1^4} + \frac{(R+y)x^2}{r_2^4} - \frac{1}{d}\right]$$

$$\sigma_y = \frac{-2P}{\pi t}\left[\frac{(R-y)^3}{r_1^4} + \frac{(R+y)^3}{r_2^4} - \frac{1}{d}\right]$$

$$\tau_{xy} = \frac{2P}{\pi t}\left[\frac{(R-y)^2 x}{r_1^4} - \frac{(R+y)^2 x}{r_2^4}\right]$$

FIG. 3.—Diagram Showing the Loaded Disk and the Resultant Stress Conditions.

data with the Mohr theory. The conclusion that can be formulated from these reports is that, for general applications, the octahedral stress theory is more complex without a corresponding increase in precision and understanding. The assumption of two-dimensional stress and ease of application would seem to dictate the use of the Mohr failure theory for the mathematical analysis of the indirect tension test.

Theoretical Study of the Indirect Tension Test

Assuming plane stress and considering a circular disk with concentrated loads on the diameter (Fig. 3), three general equations can be used to express the stress conditions at all points within the disk as shown (10–13).

Considering points between OC on the horizontal X axis: $y = 0$ and $r_1 = r_2 = \sqrt{x^2 + R^2}$. Both stresses vanish at the circumference and reach maximum values at the center. The stresses at the center are $\sigma_x = \dfrac{2P}{\pi t d}$, $\sigma_y = \dfrac{-6P}{\pi t d}$.

Therefore, the compressive strength needs to be at least three times the tensile strength in order to ensure a tensile failure.

Along the Y axis: $x = 0$, $r_1 = R - y$, $r_2 = R + y$; and $\tau_{xy} = 0$, $\sigma_x = \dfrac{2P}{\pi t d}$, $\sigma_y = \dfrac{-2p}{\pi t}\left[\dfrac{2}{d - 2y} + \dfrac{2}{d + 2y} - \dfrac{1}{d}\right]$.

The solution to this problem is based on a disk carrying compression along two semicircular grooves. If these grooves become small in comparison to the diameter, the resulting stress distribution also becomes the solution for the statically equivalent concentrated loads P, which replace the distributed loads in the grooves. However, a horizontal force P/π must be introduced for equilibrium along the AB plane. With these forces (P/π), applied at A and B the resulting tensile stress distribution is constant over the vertical cross-section. This investigation indicates that tensile failure of the specimen could start at any point along the vertical AB axis due to the even distribution of tensile stresses.

The compressive stress on this axis increases from $\sigma_y = \dfrac{-6P}{\pi d t}$ at the center to $\sigma_y = \infty$ at the loading points. With a concentrated load, the specimen will fail at the load points due to the compressive stresses and not in the central part of the specimen due to the tensile stress.

It has been shown with photoelastic studies that this point of maximum stress can be moved away from the boundary by using a distributed load. The movement of the maximum stress into the cylinder will reduce any stress concentrations due to edge effects. Also the distributed load will change the σ_x stress from tension to compression in the vicinity of the plate. This will, in effect, place the concrete under the plate in a state of stress similar to that in the triaxial test. Apparent concrete strength is increased under these conditions. Experimental evidence indicates that this condition is sufficient to retard the compressive failure at the load points so that the cylinder fails due to the tensile stress at the center. It is very important, therefore, to consider some sort of soft plate to distribute the load to the specimen.

The plate material and size will have a definite effect on the stresses directly

under the plate. Parasitic stresses due to plate expansion would seem to be beneficial in that they would provide loads to the cylinder similar to those assumed for uniform distribution of tensile stress with point loads. This observation is confirmed by comparing strain measurements of cylinders with masonite plates and cylinders with cardboard plates. Soft cardboard plates seem to provide the necessary load and stress distribution. However, theoretical considerations indicate that both plate material and plate size will vary as the ratio σ_t/σ_c varies. Plate characteristics are also dependent on the shape of the Mohr failure envelope.

The general stress equations due to a distributed load reduce in the center to the same relationships that were derived for point loads: $\sigma_x = \frac{2P}{\pi td}$ and $\sigma_y = \frac{-6P}{\pi td}$ This is confirmed from photoelastic studies which indicate that plate effects are quite localized. However, the tensile stress is generally unchanged over approximately three-quarters of the specimen. Both σ_x and σ_y are compressive directly under the plate. Failure on the circumference is retarded by the compressive stresses, and the cylinder fails in the central portion due to tensile stress. The general equation for computing tensile stress in this test is: $\sigma_x = \frac{2P}{\pi td}$.

The plate characteristics give rise to different rupture possibilities (Fig. 4). The heavy shattering in the specimen without the plate was due to high compressive stresses around the load point, and the double cleft failure in the specimen with the very wide plate was due to shearing stresses under the widely distributed load. These results can be predicted from the mathematical study, but experimental evidence indicates that these predictions are only general at best.

Perhaps the biggest assumption in the theoretical development is that the elastic hypothesis holds true until failure. This idea is supported by many who feel that, apart from single points, the failure process of brittle materials may be considered elastic. This conclusion is drawn from the fact that the formation of cracks consists of a movement directed normal to the fracture surface and sometimes has a very limited extension.

Aside from this, the plasticity of the material, if there is some, will generally produce stress relief which would tend to ensure uniform stress. The plasticity will attenuate the high compressive stresses at the load points and equalize

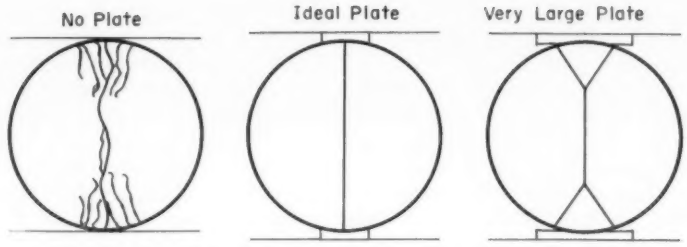


FIG. 4.—Diagram Showing Types of Rupture from Different Plate Sizes.

TABLE I.—TEST RESULTS FOR HIGH-STRENGTH CONCRETE CYLINDERS.

Cylinder Number	Mold Type	28-Day Compressive Strength, psi	Tensile Strength, psi	Fracture Characteristics
No Plate:				
5-3	C	{6370 / 5700}	491	Bad shattering; uneven break
7-1	S	{6950 / 6190}	519	Some shattering and evidences of crushing; good break
8-1	C	{6750 / 6300}	548	Shattering; very rough break
12-1	C	{6700 / 7200}	500	Pulpy break; large pieces of stone; very brittle fracture
¾-in. Plate:				
7-2	C	{6950 / 6190}	524	Bad shattering with an obvious compressive region of failure
1-in. Plate:				
3-2	S	{6060 / 6140}	663	Bad shattering with a compressive region; Uneven break
1¼-in. Plate:				
9	S	{7060 / 6110}	554	Very bad shattering; little fragments; disintegration
10	S	{5760 / 6430}	479	Bad break; pulpy split that did not fracture through to the center
11-1	S	{6100 / 7050}	505	Bad shattering with a compressive zone that shattered
12-2	S	{6700 / 7200}	509	Double cleft; shattering; clefts that extended to the center
1½-in. Plate:				
1	S	{5870 / 6430}	536	Cleft failure; uneven break with shattering
2-1	S	{5400 / 4650}	426	Good break; no secondary cracks
2-2	C	{5400 / 4650}	464	Very good break; no shattering
4	S	{6120 / 6800}	536	Very bad shattering with a compressive zone
5-2	S	{6370 / 5700}	519	Very good break; clefts formed, but did not fail to the center
6	C	{5800 / 5500}	447	Very good break
11-2	C	{6100 / 7050}	447	No shattering; uneven break
1¾-in. Plate:				
8-2	S	{6750 / 6300}	486	Some shattering with a cleft type failure
2-in. Plate:				
5-1	C	{6370 / 5700}	494	Very good break; no secondary cracks
Heavy Cardboard (Very Wide):				
3-1	C	{6060 / 6140}	554	No shattering; rough break; cleft formation and failure

the stress concentrations in the tensile region. Both of these conditions, if present, are desirable in this test.

Test Results with High-Strength Concrete

The author used this test for a series of seven 6 by 12-in. concrete cylinders that were tested for the field control of allowable tension in prestressed concrete beams. The results of the tests and the reproducibility of the rupture characteristics warranted a complete investigation into the merits of this test for field control of concrete.

A second series was conducted on 20 high-strength concrete cylinders. Forty-eight cylinders were also tested in compression so that the tension-compression ratio could be correlated with the results of other researches (Table I). These cylinders were representative samples of concrete used in the casting of 150 prestressed concrete beams. The concrete was made with type III cement, and the cylinders were steam-cured with the beams. Cylinders from steel and cardboard molds were selected for the test in order to investigate the surface conditions on test results.

Rupture characteristics and observed strengths did not seem to be dependent on the type of cylinder mold. The rough surface conditions of cylinders cast in cardboard molds seemed to have little effect on the test results. This should be expected if the cylinder fails internally due to the tensile stress and is free from the surface effects.

The results of the tests (28-day tensile strength) were plotted using 28-day compressive strengths, and were in good agreement with results found by others (Fig. 5) who have used the test. The general scatter of results is explained by the fact that all cylinders were field cast and cured and variable plate widths were used when they were tested. The test series was designed to investigate the effect of test variables rather than to determine numerical relationships. However, even with these test variables, the results compare favorably with other tensile strength determinations. This would indicate that the variables are important for exact laboratory determinations of tensile strength but that present test procedures are satisfactory for field determination of tensile strength.

Photographs of the fractures have been included to illustrate the type of failure obtained. Attention is called to the fact that the single-cleft failure always started at the bottom side of the cylinder (Fig. 6). This is the side of the cylinder that is

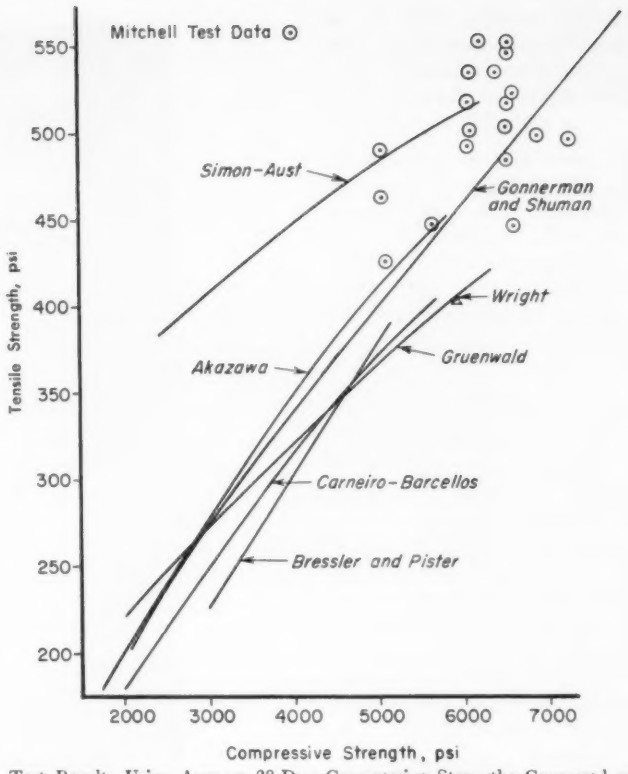


Fig. 5.—Test Results Using Average 28-Day Compressive Strengths Compared with Results Obtained by Others.

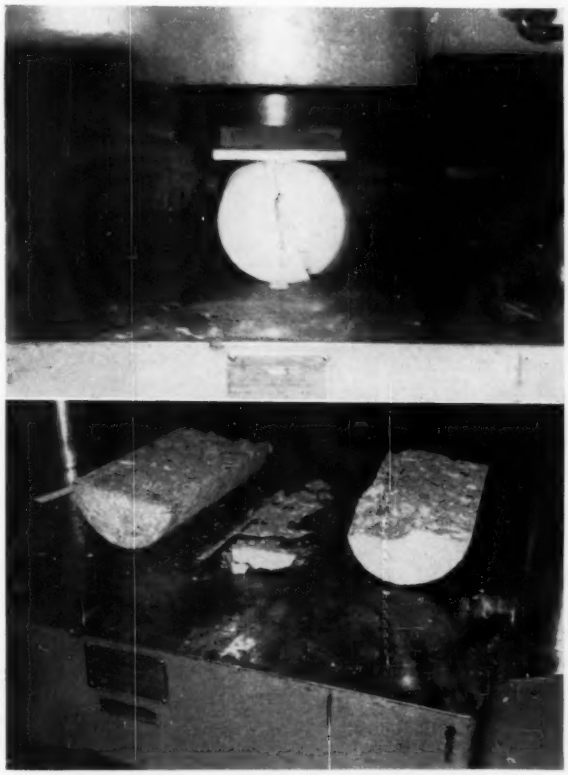


Fig. 6.—Single Cleft Failure at the Bottom of the Cylinder.

loaded with the moving head of the machine. All failures of this type occurred with small plates or no plates at all. This type of failure also occurred with masonite plates.

Indications of tensile fracture can be seen in the photographs which show fractured parts of the same aggregate in each section of the specimen (Fig. 7). Aggregate splitting took place throughout the cylinder from the center to the edge. The specimens photographed had fractured perfectly on the cylinder diameter.

Effect of Moisture and Testing Speed

Several additional cylinders were tested to determine the effect of moisture on rupture characteristics. Moist cylinders tended to break with a "soft" slow fracture, while oven-dried cylinders exploded with a great deal of shattering. In general, the wet cylinders failed at lower loads with very good breaks. It would seem that moisture lowers the tensile strength, but a great deal of work is needed to confirm these results.

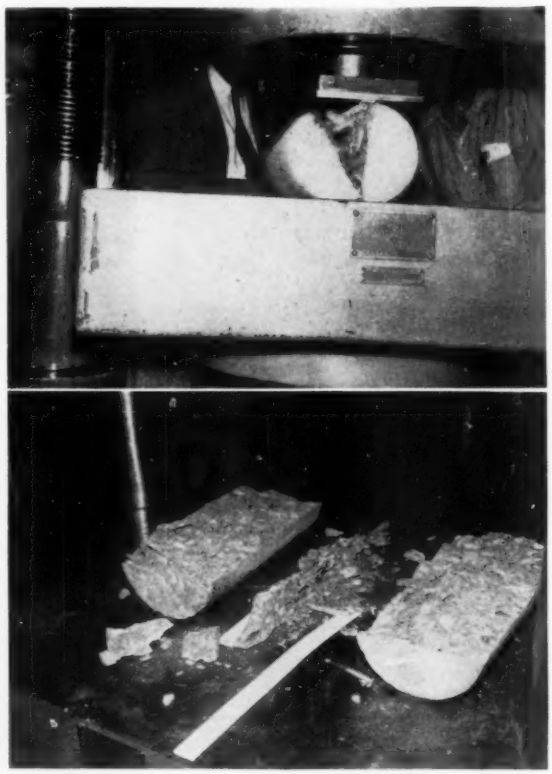
Increased speed of testing resulted in higher observed tensile strengths. In the reported tests, the machine was operated at a speed such that there was a slight continual load increase. This speed allows removal of the load as soon as failure starts, ensuring a measure of the internal tensile stress. Cylinders tested in this manner usually have not failed to the circumference, and on removal from the testing machine will split when given a sharp tap.

Effects of Plate Size

Based on the theoretical investigation, cardboard strips of varying sizes were selected for use as plates between the loading surfaces of the testing machine and the specimen. The width of these plates varied from $\frac{3}{4}$ in. to 2 in. The test results indicated that the plate size did not radically affect the strength of the specimens but did affect the rupture characteristics.

Wright (3) found little variation in results when he made small changes in his plate width ($\frac{1}{2}$ in. to 1 in.), and Gruenwald (5) and Simon and Aust (6) obtained uniform results with small plates. The author, however, found that plate size definitely influenced the type of rupture. Larger plates usually resulted in cleaner breaks. The small plates caused shattering, while the large ones caused double-cleft failures with large pieces which, in some cases had not split com-

Fig. 7.—Fractured Parts of Same Aggregate in Each Section of the Specimen.



(*a*)

(*b*)

Fig. 8.—Use of Intermediate Size Plates Produced (*a*) Ideal and (*b*) Extreme Fracture Characteristics.

pletely to the central fracture. Both types of failure can be predicted by theoretical considerations of plate size and characteristics.

The extremes of plate size produced the expected types of failure, but intermediate-size plates did not always give the expected results, producing fracture characteristics that were ideal to extreme (Fig. 8). Based on these tests, the $1\frac{1}{2}$-in. cardboard plates seemed generally satisfactory. In future testing the type of fracture should be reported along with the plate type and dimensions.

Effects of Plate Type

Two 6 by 12-in. concrete cylinders were tested with strain gages on their faces (Fig. 9) using cardboard plates for the first test and masonite plates for the second.

In the first test, with cardboard plates, the strain increased constantly up to the failure load. As expected, the strain was almost the same over the face of the cylinder, with the central gage recording the highest strain (Fig. 10(*a*)).

In the second test using masonite plates, the strain increased constantly over the face as in the first test. For the same load, the strains were similar to the first test, but almost at the failure strain of the first test, there was a strain reversal and the specimen failed from the bottom (Fig. 10(*b*), 11). Final failure was similar to that noted with small plates, that is, single-cleft failure at the bottom. The wide masonite plates caused rupture characteristics similar to those with narrow cardboard plates. From this and other test evidence obtained by the author it seems that masonite plates do not provide good bearing over their entire width.

Wright (3) used wood, steel, and rubber plates for his tests and suggested that the wooden plates be adopted. Simon and Aust (6) presented extensive test data based on tests with wooden plates. Gruenwald (5) used strips of rawhide as a plate material.

The experience with cardboard would indicate that this is an adequate, if not ideal, plate material. Steel plates and masonite plates would seem to be too rigid for satisfactory load distribution, and rubber plates seemed to deform too much. A material such as cork does not seem to supply the necessary parasitic stresses. Exact tensile stress determinations will be dependent on additional research on plate materials.

Effect of Cylinder Size

Carneiro and Barcellos (1), Akazawa (2), and Wright (3) all investigated the use of different sizes of cylinders and all were in agreement that the size of the cylinder had very little effect on the test results. However, the larger cylinders tended to provide a smaller coefficient of variation. A reasonable requirement for specimen size would be the standard 6 by 12-in. compression cylinder and the limitations of the standard compression test relating to aggregate.

Cylinders of Keene's Cement

In order to minimize aggregate and shrinkage effects and also to control the

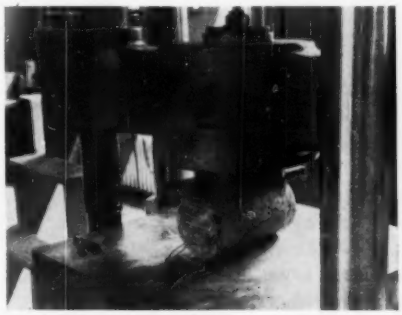


Fig. 9.—Concrete Cylinder Being Tested with Strain Gages on Its Face.

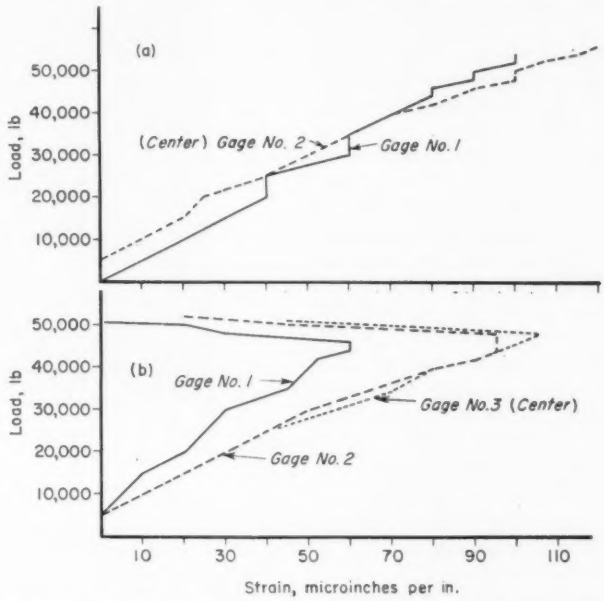


Fig. 10.—Strain Gage Results with (*a*) Cardboard Plates and (*b*) Masonite Plates.

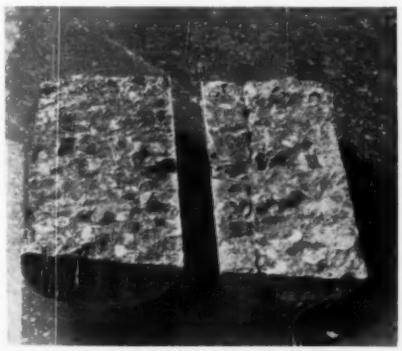


Fig. 11.—Failure of Specimen with Use of Masonite Plates.

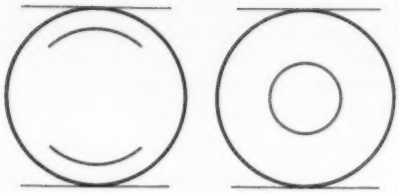


FIG. 12.—Method of Reinforcing Keene's Cement Cylinders.

casting and curing procedure, a series of tests were made on 3 by 6-in. cylinders of Keene's cement. This material possesses the desired properties of shrinkage, fineness, and very high strength.

The first 24 cylinders were cured in a fog room then removed and tested after one day at constant temperature and humidity. The cylinders had an average tensile strength of 226 psi with a coefficient of variation of 6 per cent. However, the cylinders were still damp internally and obviously had not attained their maximum tensile strength. The failures noted in these tests were perfect splits into identical halves as if the cylinders had been carved.

Two Keene cement cylinders were reinforced as illustrated in Fig. 12 and tested while still damp. It was possible to isolate the failure in the central portion of the specimen by retarding the crack with wire mesh.

These tests seemed to indicate that even better results could be expected on perfectly cured cylinders. A group of 60 cylinders, 18 briquets, and 18 cubes were cast and dried over anhydrous calcium chloride in accordance with ASTM Methods of Testing Gypsum and Gypsum Products (C 26–56).[2] These cylinders reached observed tensile strengths of about 900 psi, but the type of fracture was decidedly different as there was a gouging out of the cylinders (Fig. 13) along with the central failure.

These failures were along the photoelastic fringe lines of a point-loaded disk. The isochromatic lines are lines of constant

$$\Delta = p - q = \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$

and may be interpreted as loci of constant intensity of maximum shearing stress. This type of failure using the indirect tension test procedure has never been reported. Consideration of the Mohr failure envelope gave an indication that this type of failure was to be expected with this material.

[2] ASTM Methods of Testing Gypsum and Gypsum Products (C 26 – 56), 1958 Book of ASTM Standards, Part 4, p. 297.

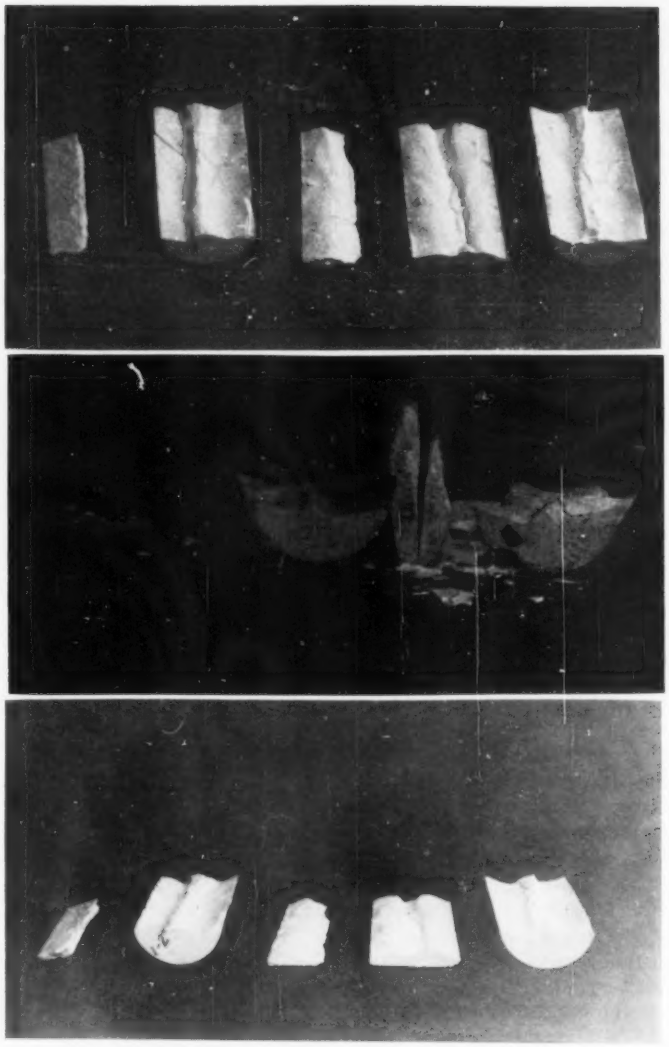


FIG. 13.—Type of Fracture with Keene's Cement Cylinders, Showing Both Central Failure and Gouging Out of Cylinders.

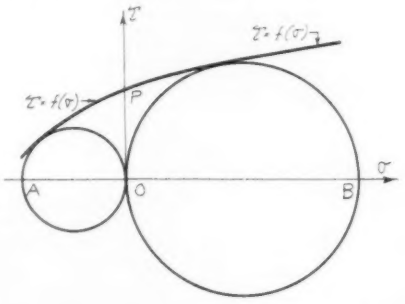


FIG. 14.—Mohr Diagram Representing Tension, Compression, and Shear Stress with Failure Envelope.

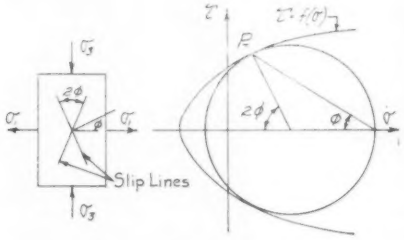


FIG. 15.—Diagram Showing Slip Angles and Mohr Envelope.

MOHR'S FAILURE ENVELOPE THEORY

The determination of the tension, compression, and shear stress at failure will lead to the two circles as shown in Fig. 14. The diameter OA represents simple tension at failure. The limiting curve, $\tau = f(\sigma)$, is the envelope of the largest principal stress circles, and the points of tangency of the major stress circles with this enveloping curve must represent, in their abscissas and ordinates (σ, τ), the normal and shearing stress in the planes of slip.

Mohr's theory accounts for the fact

that the slip angle ϕ depends on σ_1 and σ_2 (Fig. 15). It is to be noted that in ductile materials these angles of the slip plane may differ considerably from 45 deg. For ductile materials, the tensile and compressive strengths at the yield point become equal, and Mohr's "enveloping curve" degenerates into two straight lines parallel to the σ axis (Fig. 16). For this condition, the Mohr theory coincides with the theory of maximum shearing stress.

The shape of the Mohr failure envelope and, more specifically, its application to concrete has been the subject of many reports. In his original paper, Mohr (14) proposed a straight line as the failure envelope. Caquot (9) has proposed a curve having the equation $\sigma_3 = K\tau^\gamma - \sigma_0$, and Balmer (15) recommends a curve based on a least-squares analysis of extensive triaxial tests $\sigma_3 = 0.005\sigma_1^{1.37} - 430$ for 28-day concrete and $\sigma_3 = 0.0074\sigma_1^{1.33} - 480$ for 90-day concrete. Parnot (9) has proposed an equation of the form of a semi-cubic parabola $\sigma_3 = K\sigma^2 + K^1$ and Leon (16) suggests a simple parabola $\sigma_3 = K\sigma + K^1$. There are as many Mohr envelopes as there are values of the parameter $\alpha = \frac{\sigma_1}{\sigma_1 - \sigma_3}$, as demonstrated by Torre (14). From an analysis of these results, it is obvious that the properties of the failure envelope for concrete are based on the concrete strength and the method of testing.

However, these curves are all quite flat and their limit is a straight line. The straight-line assumption for the failure envelope has been confirmed for granular soils by Balmer (15) and others, and the assumption has been extended to concrete by Cowen, Raush, and Guralnick (9). This assumption simplifies computational procedures but could lead to misinterpretation when considering the results of the indirect tension test. However, the assumption of a straight line for Keene's cement seems justified, because of the lack of aggregate.

For Keene's cement, the ratio of σ_t/σ_c was found to be 1:5 to 1:6. The slope of the failure envelope for this ratio of σ_t/σ_c is quite different from the slope of the failure envelope for concrete where $\sigma_t/\sigma_c < 1{:}10$. The increase in the ratio of σ_t/σ_c has the effect of decreasing the slope and making the envelope closer to being parallel to the σ axis. The resulting Mohr circle point of tangency to the failure envelope is almost horizontal (Fig. 17).

The slope of the failure envelope has a physical significance. When the envelope

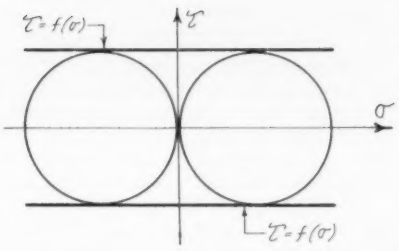


FIG. 16.—Diagram Showing Mohr Envelope for Ductile Materials.

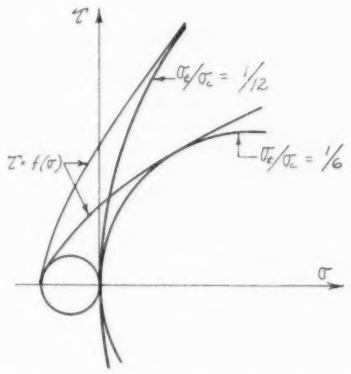


FIG. 17.—Mohr Envelope Slopes with Different Strength Ratios.

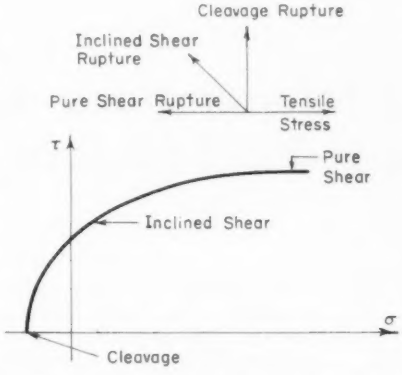


FIG. 18.—Diagram Showing Significance of Slope of Failure Envelope.

becomes parallel with the σ axis, it indicates that the failure will be the maximum shear failure, or $\phi = 45$ deg. The transitional section of the curve is indicative of an ordinary obliquely inclined shear fracture where $0 < \phi < 45$ deg. The apex of the envelope is where pure cleavage failure takes place and $\phi = 0$. When the fracture is from cleavage, the rupture is in the direction normal to the maximum tensile stress (Fig. 18).

The decreased slope of the failure envelope for a material like Keene's cement would give an indication that shear failure characteristics should be expected. Compression cubes of this material also seemed to fail due to pure shear and seemed quite unsatisfactory as a measure of the compressive strength.

These tests confirmed the fact that the indirect tension test is only reasonable as a test to measure tensile strength when the ratio of $\sigma_t/\sigma_c < 1{:}10$. These tests also indicated the importance of recording with the test results the type of failure characteristics.

CONCLUSIONS

Future studies of brittle materials should clarify the shape of the Mohr envelope, if it is in fact the best explanation of the failure phenomenon. The shape of the Mohr failure envelope should be studied for all strengths of concrete and all aggregate ratios. The effects of aggregate shape and water content, plus information on plate material, and size and thickness as they relate to the rupture characteristics, are needed for a better understanding of this test.

This test should prove worth-while for field control of high-strength concrete, especially in view of variability of compressive strength values due to the effects of various capping materials. Field considerations of making, handling, and curing would all increase the desirability of this test in comparison with other tension tests now in use.

This author has used tension test results to control allowable tension in the top fibers of partially stressed prestressed concrete beams. Indirect tension tests of cores from a prestressed concrete beam were used to predict the cracking load of the beam when it was tested. Consideration of these uses makes it clear that an adequate, easily obtained, and accurate tensile strength measurement would provide designers with information to make reasonable stress considerations of concrete structures.

The indirect tension test appears to be superior in most aspects to other tension tests now in use or proposed for use. In its present form, it appears to be much more satisfactory for field control of concrete than other test procedures. Further studies of this test should lead to a measurement of "true" tensile strength which will be more accurate for design purposes than the present methods for measuring "true" compressive strength.

Acknowledgment:

Grateful acknowledgment is made to the late Professor James A. Murray for his supervision and valuable suggestions on this problem.

References

(1) F. L. L. B. Carneiro and A. Barcellos, "Concrete Tensile Strength," *Union of Testing and Research Laboratories for Materials and Structures*, No. 13, March, 1953.

(2) Tsueno Akazawa, "Tension Test Method for Concrete," *Union of Testing and Research Laboratories for Materials and Structures*, No. 16, Nov., 1953.

(3) P. J. F. Wright, "Comments on an Indirect Tensile Test on Concrete Cylinders," *Magazine of Concrete Research*, July, 1955, pp. 87–96.

(4) B. W. Abbott and K. F. Reinschmidt, "Photoelastic Studies of the Tensile Briquet," *142 Report*, Massachusetts Inst. Technology, June, 1959; also "Tensile Testing of Concrete," Jan. 1959.

(5) Igbal Ali, E. Gruenwald, H. Rusch, and G. Vigerust, Discussion, *Journal*, Am. Concrete Inst., Vol. 29, No. 6, Paper 53-38 Dec. (1957).

(6) Leslie, L. Simon and M. I. Aust, "The Use of the Indirect Tensile Test for Quality Control of Pavement Concrete," *Construction Review*, Aug., 1956, pp. 23–29.

(7) H. F. Gonnerman and E. C. Shuman, "Compression, Flexure and Tension Tests of Plain Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part II, p. 527 (1928).

(8) B. Bresler and K. S. Pister, "Strength of Concrete Under Combined Stresses," *Proceedings*, Am. Soc. Civil Engrs., Vol. 122 (1957); also *Journal*, Am. Concrete Inst., Vol. 30, No. 3, Sept. (1958), p. 321.

(9) S. A. Guralnick, "Strength of Reinforced Concrete Beams," *Proceedings*, Am. Soc. Civil Engrs., Vol. 85, Jan., 1959.

(10) M. M. Frocht, "Photoelasticity," Vol. 2, John Wiley & Sons, New York, N. Y. (1948).

(11) S. Timoshenko and J. N. Goodier, "Theory of Elasticity," Second Edition, McGraw-Hill Book Co., Inc., New York, N. Y. (1951).

(12) R. Peltier, "Theoretical Investigation of the Brazilian Test," *International Association of Testing and Research Laboratories for Materials and Structures*, No. 19, 1954.

(13) N. B. Mitchell, Jr., "The Indirect Tensile Test for Concrete," Thesis submitted in partial fulfillment for M.S. degree at Massachusetts Inst. Technology, Aug., 1959.

(14) A. Nadi, "Theory of Flow and Fracture of Solids," Vol. I, Second Edition, McGraw-Hill Book Co., Inc., New York, N. Y. (1950).

(15) G. Balmer, "Shearing Strength of Concrete Under High Triaxial Stress and Computation of Mohr's Envelope as a Curve," *Structural Research Laboratory Report No. SP-23*, U. S. Bureau of Reclamation, Oct., 1949.

(16) A. Leon, "Uber die Scherfestigkeit des Betons," *Beton und Eisen*, Vol. 34, April 20, 1935, pp. 130–135.

(17) D. McHenry and J. Karni, "Strength of Concrete Under Combined Tensile and Compressive Strength," *Journal*, Am. Concrete Inst., Vol. 29, No. 10, April (1958).

(18) Sven Thalow, "Tensile Splitting Test and High Strength Concrete Test Cylinders," *Journal*, Am. Concrete Inst., Vol. 28, No. 7, Paper 53-38, Jan. (1957).

(19) L. E. Young, G. M. Smith, and J. S. Blackman, "Stress Distribution Affects Ultimate Tensile Strength," *Journal*, Am. Concrete Inst., Vol. 30, No. 6, Dec. (1958).

(20) F. Richart, A. Brandzaeg, and R. L. Brown, "A Study of the Failure of Concrete Under Combined Compressive Stresses," *Bulletin No. 185*, University of Illinois, Urbana, Ill. (1928).

(21) W. Weibull, "Investigations into the Strength Properties of Brittle Materials," The Royal Swedish Institute for Engineering Research, *NR 149*, Jan. (1938).

(22) W. Weibull, "The Phenomenon of Rupture in Solids," The Royal Swedish Institute for Engineering Research, *NR 153*, May, 1939.

Effects of Elevated Temperatures on Mechanical Properties of Type H-7213 Micarta (Astrokon)[1]

By S. Y. LU and WILLIAM A. NASH

The influence of rapidly attained high temperatures on mechanical properties of type H-7213 Micarta (Astrokon) was investigated experimentally. The environments considered were: (1) heating to approximately 1200 F in 15 sec, then loading in tension at a strain rate of approximately 0.25 in. per in. per sec, during which phase the effect of various numbers of cycles of heating and cooling prior to loading at a peak temperature of about 1200 F were also considered; and (2) heating to approximately 1200 F in 15 sec, followed by various lengths of time in which the temperature is held constant prior to loading at a constant strain rate.

EXISTING INFORMATION on mechanical properties of type H-7213 Micarta (Astrokon) is limited to the data supplied by the manufacturer. This indicates a room-temperature tensile strength of approximately 41,000 psi corresponding to a strain of 0.016.

This investigation was made to provide basic information concerning the mechanical properties of this material at elevated temperatures and strain rates of approximately 0.25 in. per in. per sec. Temperatures ranged from room temperature to approximately 1200 F, with the peak value attained in 15 sec.

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[1] These results were obtained in the course of research sponsored by the Army Ballistic Missile Agency under Contract DA-01-009-ORD-656 with the University of Florida.

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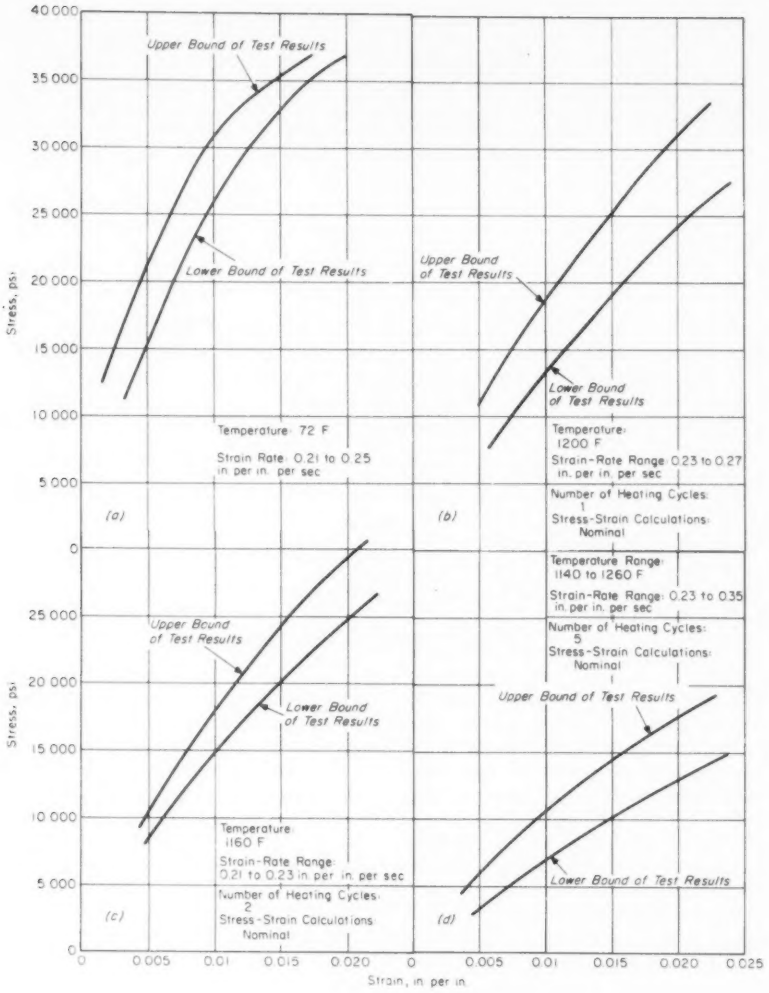
WILLIAM A. NASH, head of the Advanced Mechanics Research Section at the University of Florida, received his Ph.D. from the University of Michigan in 1949. Since then he has been active in teaching and research in the field of engineering mechanics.


Upper Bound of Test Results
Lower Bound of Test Results
Temperature: 72 F
Strain Rate: 0.21 to 0.25 in. per in. per sec
(a)
Upper Bound of Test Results
Lower Bound of Test Results
Temperature: 1200 F
Strain-Rate Range: 0.23 to 0.27 in. per in. per sec
Number of Heating Cycles: 1
Stress-Strain Calculations: Nominal
(b)
Upper Bound of Test Results
Lower Bound of Test Results
Temperature: 1160 F
Strain-Rate Range: 0.21 to 0.23 in. per in. per sec
Number of Heating Cycles: 2
Stress-Strain Calculations: Nominal
(c)
Temperature: 1140 to 1260 F
Strain-Rate Range: 0.23 to 0.35 in. per in. per sec
Number of Heating Cycles: 5
Stress-Strain Calculations: Nominal
Upper Bound of Test Results
Lower Bound of Test Results
(d)
Stress, psi
Strain, in. per in.

(*a*) At room temperature.
(*b*) For one heating cycle. No initial stress in coupon.
(*c*) For two heating cycles. No initial stress in coupon.
(*d*) For five heating cycles. No initial stress in coupon.

Fig. 1.—Stress-strain characteristics.

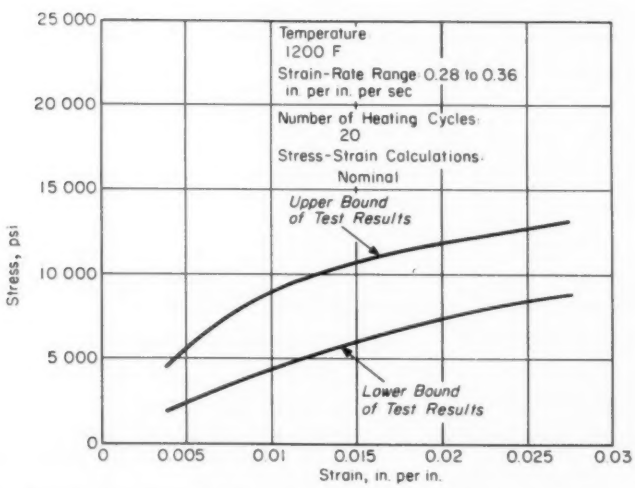

Temperature: 1200 F
Strain-Rate Range: 0.28 to 0.36 in. per in. per sec
Number of Heating Cycles: 20
Stress-Strain Calculations: Nominal
Upper Bound of Test Results
Lower Bound of Test Results
Stress, psi
Strain, in. per in.

Fig. 2.—Stress-strain characteristics for 20 heating cycles. No initial stress in coupon.

Test Specimens and Apparatus

Standard-size ASTM flat coupons with a gage length of 2.00 ± 0.02 in., a mean thickness of 0.125 in., and a nominal width of 0.5 in. were used. Elongations of the gage length were monitored by cantilever-beam-type transducers bearing electric strain gages calibrated to indicate the displacement of the tips of the cantilevers. The tips rested against very small triangular protrusions at each end of the gage length. Preliminary investigations indicated that these protrusions did not affect the stress-strain characteristics of the specimen. Although elongation was monitored continuously from the condition of zero stress, the strain-gage response was not recorded on the oscillograph until plastic action had begun. Hence, the elastic deformations are not indicated in the stress-strain diagrams presented. All strains indicated anywhere in this study are due solely to the effects of the axial tensile forces; they do not include thermal expansion.

A special-purpose tension test machine[2] was designed and built to provide the desired constant strain rate of about 0.25 in. per in. per sec. The machine was a variable-speed, positive-drive mechanical unit.

Induction heating was selected because it made possible accurate programming of any desired temperature-time relation. Because of the low conductivity of Micarta, a piece of thin flat steel was placed between the induction-heating coil and the specimen. Three chromel-alumel thermocouples were welded to the steel. For each environment, a preliminary specimen was instrumented with thermocouples on the surface of the Micarta in order to obtain a calibration relating the temperature on the surface of the steel plate to the temperature on the heated surface of the Micarta. The recorded temperature on Micarta had a variation less than 50 F. The other surface of the Micarta was held at nearly room temperature by a blower. When the specimen was first heated from room temperature, the temperature-time relation comprised a rise rate of 50 F per sec for the first 7 sec followed by a rise rate of 100 F per sec for the last 8 sec. The gradient was controlled by a closed-loop control system. The desired temperature-time relations were generated by a function generator in the system. A 20 kw radio-frequency generator with an operating frequency of 2 Mc per sec was used as the power source. Power was coupled into the steel by the magnetic field produced by the radio-fre-

[2] S. Y. Lu, Marc Trubert, and W. A. Nash, "Elevated Temperature Characteristics of 347 Stainless Steel," Contract No. 01-009-ORD-656, Engineering and Industrial Experiment Station, University of Florida (Gainesville), to be published in ASTM *Proceedings* (1961).

quency currents. The temperature, load, and elongation signals were recorded simultaneously on a multichannel recording oscillograph.

Test Program

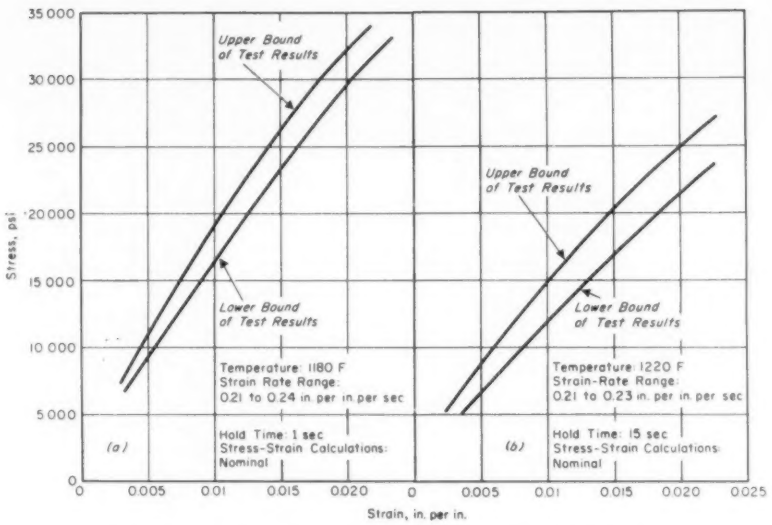
Phase I.—Room-temperature tension tests were made first. The results of these tests are indicated in Fig. 1(*a*). The two curves do not represent results of any specific tests; they are the extreme bounds on all test results. The original cross-sectional areas were used in all stress and strain calculations.

Next, specimens were heated from room temperature to approximately 1200 F in 15 sec. While this temperature was held constant, the specimen was loaded to fracture at a constant strain rate of approximately 0.25 in. per in. per sec. The results of these tests are shown in Fig. 1(*b*).

The next series of coupons was subjected to a temperature rise from room temperature to approximately 1200 F in 15 sec, then cooled to 400 F in 3.50 min, and immediately reheated to approximately 1200 F in 13 sec. While this temperature was held constant at 1200 F, the test coupon was loaded to fracture at a constant strain rate of approximately 0.25 in. per in. per sec. The results of the two-cycle heating are shown in Fig. 1(*c*).

In a similar manner, the stress-strain characteristics for 5 and 20 cycles of heating and cooling prior to loading at the peak temperature of about 1200 F were obtained. The results are shown in Figs. 1(*d*) and 2.

The curves shown in Figs. 1(*b*), (*c*), (*d*) and 2 represent extreme bounds on all test results; they are not results of any specific tests. For each thermal condition, 3 or 4 specimens were tested. The results were acceptable only when all recording and controlling equipment was functioning correctly. Also indicated in these figures are the test temperature ranges and the ranges of strain rates for all tests conducted.



(*a*) For a constant temperature of approximately 1200 F held for 1 sec prior to loading.
(*b*) For a constant temperature of approximately 1200 F held for 15 sec prior to loading.

Fig. 3.—Stress-strain characteristics.

Phase II.—Mechanical properties under conditions of various hold times at approximately 1200 F were determined during this phase. The specimens were heated to approximately 1200 F in 15 sec. This temperature was held constant for a predetermined period of time, and at the end of this time the specimen was loaded to fracture at a constant strain rate of approximately 0.25 in. per in. per sec.

Tests were conducted for hold times of 1 and 15 sec. Results are shown in Figs. 3(*a*) and (*b*). The two curves shown in each figure again represent upper and lower bounds on all test results.

Results and Conclusions

Phase I.—The results shown in Figs. 1(*b*), (*c*), (*d*) and 2 indicate that the tensile strength of the material decreases rapidly with an increase in the number of cycles of heating and cooling between approximately 1200 and 400 F. For one cycle of heating, the mean tensile strength is approximately 31,000 psi; for two cycles, it is approximately 28,000 psi; for five cycles, 18,000 psi; and for 20 cycles, approximately 11,000 psi. At the same strain rate (about 0.25 in. per in. per sec) the room-temperature tensile strength is approximately 36,000 psi.

Phase II.— Figures 3(*a*) and (*b*) indicate that the effect of holding the temperature constant, after a temperature of 1200 F has been attained, is to decrease the tensile strength of the material. For example, the tensile strength after holding at 1200 F for 1 sec is approximately 34,000 psi; whereas, after 15 sec of holding at this same temperature, it is only 25,000 psi.

"International trade . . . is a great dialogue for which nations must find a common language. That common language is industrial standards.

If the industrialization of Latin America is a major battle in the Cold War, then industrial standards are strategic weapons in our arsenal."

T. A. MARSHALL, JR.

(See p. 808)

Quick and False Set in Portland Cements

By W. C. HANSEN

This paper is largely a review of the information from the principal and discussion papers on false set presented at the Fourth International Symposium on the Chemistry of Cement.[1] False set is defined as stiffening produced by crystallization of gypsum in the cement paste, and quick set as stiffening produced by the reactions of C_3A and C_4AF with water. Data are presented to show that some cements containing dehydrated gypsum may not show false set until aeration reduces the rate at which C_3A reacts with $CaSO_4$. The paper also shows that some cements may develop quick set by aeration, reducing the ability of C_3S to release $Ca(OH)_2$ to the solution to control the reactions of C_3A and C_4AF with water.

THE FOURTH INTERNATIONAL Symposium on the Chemistry of Cement[1] provided an opportunity for a thorough review of our knowledge of the problem of false and quick set in cement and an opportunity for investigators throughout the world to present new data and theories. It seems desirable to review what appear to be the salient facts developed in that symposium in order to make them more readily available to the technical people who are responsible for the production and use of portland cement. This is the purpose of this paper. The reader is referred to the *Proceedings* of the Symposium (1)[2] for most of the references to the published literature and for most of the data.

Normal, False, and Quick Set

ASTM Committee C-1 on Cement recently adopted the following definitions for false and quick set:

1. False set is the rapid development of rigidity in a mixed portland cement paste, mortar, or concrete without the evolution of much heat, which rigidity can be dispelled and plasticity regained by further mixing without addition of water. Grab set, premature stiffening, hesitation set, early stiffening, and rubber set are terms referring to the same phenomenon but false set is the preferred term.

2. Quick or flash set is the rapid development of rigidity in a mixed portland cement paste, mortar, or concrete, usually with the evolution of considerable heat, which rigidity cannot be dispelled nor can plasticity be regained by further mixing without addition of water. Quick set is the preferred term.

The use of the adjectives "false" and "quick" indicates that one characteristic of a portland cement is a property that may be classed as normal set. However, it is well known that calcium sulfate is used with some clinkers to produce cements that will yield concretes that do not stiffen too rapidly to be placed satisfactorily. It is also well known that the rates at which powdered clinkers develop their early strengths are accelerated by adding calcium sulfate. It seems obvious, therefore, that, when the term "normal set" is inferred, it applies to a property that has been built into the cement by using calcium sulfate to modify the rates at which the clinker minerals react with water.

It is now known that the compositions of the compounds in portland cement clinker vary slightly from those of the simple binary and ternary compounds represented by the following formulas: $3CaO \cdot SiO_2$; $2CaO \cdot SiO_2$; $3CaO \cdot Al_2O_3$; and $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$, which have been studied by many investigators for rates of reaction with water. However, there appears to be no evidence to show that the cement compounds react with water at markedly different rates from those of the pure compounds. If this is true, then the compounds responsible for rapid stiffening of a cement paste are the calcium aluminate and calcium aluminoferrite phases. For simplicity, these will be referred to as C_3A and C_4AF, and the silicate phases will be referred to as C_3S and C_2S, although the composition of the aluminoferrite phase may differ markedly from C_4AF.

It appears to be established beyond question that calcium sulfate is added

TABLE I.—DATA FROM MEADE (2).

Calcium Sulfate Added, per cent	Water Used in Pats, per cent	Initial Setting Time, hr:min[a]		
		Gypsum	Plaster of Paris	Dead-Burned Gypsum
0	25	0:02	0:02	0:02
0.5	23	...	0:05	...
1.0	23	0:02	0:50	0:06
1.5	23	...	2:50	...
2.0	22	2:40	3:00	1:45
3.0	22	2:50	1:45	1:47
4.0	22	...	0:35	...
5.0	22	3:15	0:16	2:00
10.0	22	3:00	0:16	1:50
20.0	22	3:20	0:09	2:20

[a] Gillmore needle for type of calcium sulfate indicated.

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[1] Fourth International Symposium on the Chemistry of Cement, Washington, D. C. (1960).

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

to cements to retard the rate of reaction of C_3A and possibly that of C_4AF with water to produce what may be classed as normal-setting cements. In other words, without this modifier, certain clinkers produce quick-setting cements.

One of the early investigators of the use of calcium sulfate for this purpose was Meade (2). He made studies with gypsum, plaster of Paris, and dead-burned gypsum with the results shown in Table I. Examination of these data shows the following:

1. Calcium sulfate as gypsum in amounts of 2.0 to 20.0 per cent gave initial setting times of 160 to 200 min. Any cement that had an initial setting time within this range might be classed as a normal-setting cement. It is interesting to note that additions of calcium sulfate up to 2.0 per cent markedly reduced the rate of setting and that increases beyond this amount produced very little further retardation. This is an important observation, because it is not uncommon today to find technologists suggesting that the quick-setting characteristics of a cement might be eliminated by increasing its SO_3 content beyond about 2.0 per cent.

2. Increasing amounts of calcium sulfate as plaster of Paris increased the initial setting time from 2 min until a maximum of 180 min was reached with 2.0 per cent. The initial setting time then decreased until it reached 9 min with 20.0 per cent of calcium sulfate. The stiffening that occurred after the setting time reached a maximum is now known to have been caused by crystallization of gypsum in the paste due to rapid solution of hemihydrate. This is what is now classed as false set and is covered by the above definition of false set. If one would define the normal initial setting time at 60 to 200 min, then with 0.5 per cent calcium sulfate as plaster of Paris, this cement was markedly quick-setting (5 min), whereas, with 1.0 per cent, it was very mildly quick-setting (50 min).

3. Calcium sulfate beyond 2.0 per cent as gypsum had only a minor effect on the initial setting time, whereas, when in the form of plaster of Paris, it had a marked effect in decreasing the setting time. As pointed out above, this effect is now known to be caused by the crystallization of gypsum resulting from the rapid solution of the plaster of Paris, which produces a solution that is supersaturated with respect to gypsum. In terms of the above definition for normal setting (60 to 200 min), 3.0 per cent of calcium sulfate as plaster of Paris did not produce false set (105 min), whereas 4.0 to 20.0 per cent produced severe false set (35 to 9 min).

4. Addition of calcium sulfate as dead-burned gypsum, which should have been similar in rate of solution characteristics to natural anhydrite, produced normal-setting cements, in terms of the above definition, with 2.0 to 20.0 per cent, the setting times varied between 105 and 140 min. Hence, all three forms of calcium sulfate satisfactorily retarded the setting time of this clinker.

Calcium Sulfate

It appears that very shortly after the product from which present portland cements developed began to be rather extensively manufactured (about 1875) calcium sulfate was introduced as a material that could be ground with the clinker to retard the rate at which the clinker-water paste stiffened. This developed into the use of calcium sulfate as a universal modifier of the setting characteristics of portland cement clinkers.

We know today that this initial use of calcium sulfate was to control the rate at which C_3A reacts with water. In other words, it was used to retard the rate of a reaction that produces quick-setting cements, sufficiently to produce cements that had satisfactory stiffening properties from a commercial standpoint. It is desirable to emphasize that rapid stiffening in cement pastes may, at times, result from inadequate control of the reactions of C_3A and C_4AF with water and that rapid stiffening may vary from mild to severe. This should not be classed as a false set because there is nothing false about these reactions. In other words, this is the normal behavior of an improperly retarded cement and should be classed as quick set

Shortly after the adoption of calcium sulfate as a set modifier, the producers began to have trouble with a different type of rapid stiffening. Whereas some clinkers ground without calcium sulfate gave powders that reacted so violently with water as to give pastes that became hot and unworkable, some of the powders of clinkers ground with calcium sulfate gave pastes that stiffened rapidly but released very little heat and the stiffening could be removed by additional working. The first became known

TABLE II.—SOLUBILITY OF $CA(OH)_2$ AND $CASO_4 \cdot 2H_2O$ IN SOLUTIONS OF KOH AND NAOH AT 25 AND 30 C. (DATA BY HANSEN AND PRESSLER (3)).

Composition of Original Solution, *M*			Composition of Solution in Contact with Solid $Ca(OH)_2$ and Solid $CaSO_4 \cdot 2H_2O$, *M*				
K_2O	Na_2O	$K_2O + Na_2O$	CaO	SO_3	OH	Na_2O	$K_2O + Na_2O$[a]
Data for 30 deg Cent							
None	None	None	0.0319	0.0125	0.0387	...	0.0001
0.0050	None	0.0050	0.0298	0.0141	0.0419	...	0.0053
0.0025	0.0025	0.0050	0.0294	0.0141	0.0393	...	0.0044
0.0150	0.0050	0.0200	0.0256	0.0191	0.0529	0.0052	0.0199
0.0100	0.0101	0.0201	0.0236	0.0196	0.0477	...	0.0199
0.0251	None	0.0251	0.0228	0.0223	0.0523	...	0.0256
0.0125	0.0125	0.0250	0.0226	0.0219	0.0514	...	0.0250
0.0150	0.0151	0.0301	0.0226	0.0236	0.0585	...	0.0302
0.0251	0.0050	0.0301	0.0231	0.0241	0.0587	0.0052	0.0303
0.0150	0.0151	0.0301	0.0216	0.0252	0.0536	...	0.0304
0.0301	None	0.0301	0.0214	0.0253	0.0524	...	0.0301
0.0401	None	0.0401	0.0211	0.0299	0.0626	...	0.0399
0.0200	0.0202	0.0402	0.0198	0.0303	0.0602	...	0.0406
0.0150	0.0252	0.0402	0.0195	0.0303	0.0589	0.0251	0.0401
0.0501	None	0.0501	0.0185	0.0373	0.0618	...	0.0497
0.0251	0.0252	0.0503	0.0188	0.0376	0.0633	...	0.0502
0.0251	0.0252	0.0503	0.0194	0.0363	0.0672	0.0253	0.0505
0.0050	0.0500	0.0550	0.0184	0.0395	0.0698	0.0504	0.0561
0.0500	0.0050	0.0550	0.0190	0.0398	0.0689	0.0052	0.0552
0.0601	None	0.0601	0.0187	0.0430	0.0710	...	0.0598
0.0301	0.0302	0.0603	0.0180	0.0425	0.0711	...	0.0599
0.0150	0.0504	0.0654	0.0175	0.0468	0.0734	0.0502	0.0659
0.0501	0.0252	0.0753	0.0174	0.0544	0.0771	0.0255	0.0756
0.1002	None	0.1002	0.0162	0.0710	0.0806	...	0.0951
0.1002	0.0050	0.1052	0.0167	0.0783	0.0884	0.0056	0.1058
0.1002	0.0252	0.1254	0.0164	0.0951	0.0940	0.0259	0.1257
0.1504	None	0.1504	0.0162	0.1167	0.0972	...	0.1491
None	0.1448	0.1448	0.0150	0.1151	0.1024	...	0.1513
0.1504	0.0050	0.1554	0.0162	0.1211	0.1011	...	0.1553
0.1504	0.0252	0.1756	0.0162	0.1382	0.1048	...	0.1744
0.2005	None	0.2005	0.0164	0.1626	0.1062	...	0.1991
None	0.1930	0.1930	0.0149	0.1586	0.1146	...	0.2010
0.2506	None	0.2506	0.0161	0.2055	0.1136	...	0.2462[b]
0.1253	0.1250	0.2503	0.0169	0.2040	0.1188	...	0.2465[b]
0.3750	None	0.3750	0.0094	0.2121	0.1455	...	0.2555[b]
None	0.3750	0.3750	0.0051	0.2629	0.2279	...	0.3718
0.5012	None	0.5012	0.0093	0.2083	0.1386	...	0.2683[b]
1.0023	None	1.0023	0.0034	0.3662	0.2752	...	0.5000[b]
Data for 25 deg Cent							
None	None	None	0.0331	0.0123	0.0414	...	0.0001
0.0100	None	0.0100	0.0292	0.0151	0.0488	...	0.0103
0.0200	None	0.0200	0.0240	0.0190	0.0502	...	0.0201
0.0401	None	0.0401	0.0211	0.0289	0.0649	...	0.0403
0.0601	None	0.0601	0.0183	0.0426	0.0726	...	0.0606
0.1002	None	0.1002	0.0161	0.0722	0.0888	...	0.1005
0.2005	None	0.2005	0.0165	0.1562	0.1164	...	0.1979[b]

[a] Calculated from determined values for CaO, SO_3, and OH.
[b] $CaSO_4 \cdot K_2SO_4 \cdot H_2O$ probably formed as a solid phase.

as flash or quick set and the latter as false set or premature stiffening.

Technologists were familiar with the plasters prepared by calcining gypsum to produce hemihydrate ($CaSO_4 \cdot \frac{1}{2}H_2O$) known as plaster of Paris, and to produce an anhydrous calcium sulfate known as soluble anhydrite. During the period 1929–1933, several investigators published papers in which they explained false set as a stiffening of the paste produced by dehydrated gypsum going into solution and precipitating as gypsum, just as it does when gypsum plasters set. They explained the presence in cement of either hemihydrate or soluble anhydrite or both on the use of mills that produced relatively high temperatures during grinding.

This explanation was generally accepted, but some investigators searched for other causes of this type of rapid stiffening. However, about the only one that remains today is based on the belief that some alkali carbonates are formed during weathering of the clinker It seems unlikely that cement clinkers. can form sufficient alkali carbonate during weathering to have a marked effect upon the stiffening characteristics of the paste. However, if they did, the result would be to rob the liquid phase of the cement paste of $Ca(OH)_2$ and, accordingly, tend to cause quick stiffening. It appears, therefore, that the term false set should be used solely for the stiffening produced by the crystallization of gypsum in the cement paste. If a clinker contained a large amount of alkali sulfates, it is conceivable that the $Ca(OH)_2$ released by the hydrolysis of silicates and these readily soluble sulfates might supersaturate the solution with respect to gypsum. Such a solution could precipitate gypsum and cause false set. Hence, the formation of hemihydrate during either grinding or storage may not be the only source of false set but the crystallization of gypsum in the cement paste is the only cause of false set.

Specifications and Test Methods

Most users of cement are not troubled with false set because the mixing and placing operations are such that any stiffening produced by the crystallization of gypsum occurs at a time at which it does not interfere with the placing of the concrete. However, this is not true on all jobs, and users began about 30 years ago to search for methods of testing for false set that could be used to write specifications by which false-setting cements could be rejected. This stimulated research by both users and producers on test methods and on other problems related to the rapid stiffening of cement pastes.

One of these problems was related to aeration of cements. In many cases, cements tested for false set showed normal stiffening on samples collected during grinding but showed rapid stiffening on samples collected during packing from the silo. At times, rapid stiffening did not develop until after the cement had been in storage on the job for a few days. This behavior cast doubt on the correctness of the theory that false set was caused solely by the crystallization of gypsum and led to the studies which will be reviewed in the following sections.

The System CaO-Na_2O-SO_4-H_2O

When portland cement reacts with water, the liquid phase very quickly becomes essentially a system represented by the following reactions:

$$CaSO_4 \cdot 2H_2O(S) \rightleftarrows CaSO_4 + (MOH)_2 = M_2SO_4 + Ca(OH)_2 \rightleftarrows Ca(OH)_2(S) \ldots (1)$$

where S equals solid and M represents either Na or K or both.

Hansen and Pressler (**3**) determined the solubility relations at equilibrium in this system, and their data are reproduced in Table II. Hemihydrate and soluble anhydrite dissolve rapidly in water to give solutions that are highly supersaturated with respect to gypsum. The solubility of gypsum increases with increases in the alkali content of the solution. Hence, one must know both the SO_3 content and the alkali content of the liquid phase of a cement paste to determine whether or not it is supersaturated with respect to gypsum. The data by Hansen and Pressler have made it possible to analyze extracts from cements and ascertain with certain reservations whether or not the cements contain dehydrated gypsum. As will be brought out later, this extraction test has made it possible to reach conclusions as to what has happened in certain cement pastes during the first few minutes after preparation.

ASTM Method C 359

The Working Committee on False Set of ASTM Committee C-1 on Cement developed a method of testing for quick stiffening in cement mortars that has been found to be very useful in studying the stiffening characteristics of cements. In the Method of Test for False Set of Portland Cement[3] mixing is done by machine. It is not subject to difficulties inherent in methods dependent on hand mixing and has made it possible to detect mild degrees of stiffening that are often destroyed in methods using hand mixing.

This method has been subjected occasionally to what appears to be improper criticisms. It was well known when this method was developed that the degree of stiffening obtained in a cement paste was a function of both the water content of the paste and the time of mixing. It was also believed that all good quality portland cement clinkers ground to approximately the same fineness with adequate gypsum to prevent severe quick set should require very nearly the same quantities of water for a given consistency as measured by relatively crude tests such as the penetration of a plunger of some type into a paste or mortar. Hence, it appeared that the proper way of comparing cements would be to start with a fixed water-cement ratio for cements of approximately the same fineness and to use a relatively short mixing period. Accordingly, the water contents of the mortar were set at 30 per cent by weight of cement for type I and cements of similar fineness and at 32 per cent for type III cement.

It seems that it can be safely stated that these water-cement ratios give initial penetrations of approximately 50 mm in ASTM Method C 359 for all cements that are not moderately or severely false-setting or quick-setting. Various critics of Method C 359 have stated that it penalizes cements having high water requirements. It appears that these critics do not recognize that those are the cements that the user is attempting to reject, either because of severe quick- or false-setting characteristics.

Some technologists have assumed that a cement showed false-setting characteristics when tested by Method C 359 if the penetrations at any of the test periods were less than 50 mm. It is well known that the initial setting times of cements as measured, for example, with the Vicat needle may vary between about 45 and 300 min. One should expect, therefore, that some cements that contained very little or no hemihydrate would produce mortars that showed marked stiffening in Method C 359, whereas others would produce mortars that showed little or no stiffening in this test. The question facing the specification writer is what degree of stiffening in this or any similar test constitutes a warning that the cement is likely to perform unsatisfactorily in the field. Tests on a number of cements that showed rapid-setting characteristics in the field indicate that unsatisfactory cements show penetrations of less than 5 mm at one or more periods in this method. Such stiffening could, of course, result from either quick or false set. There is some feeling that the test would be more suitable for specification purposes if the water content of the mortar was raised sufficiently to eliminate stiffening in the test by all but severely false- or quick-setting cements. This idea may have merit, but such a modification would detract from the method for research purposes.

[3] Method C 359–56 T, 1958 Book of ASTM Standards, Part 4, p. 134.

Aeration

Data obtained with this method are used in the remainder of the paper to explain what happened to certain cements during aeration. These data show that aeration, which is believed to result in chemisorption of either H_2O or CO_2, or both, can influence the rates at which the cement minerals react with water and, accordingly, the rates at which the pastes stiffen.

From the standpoint of the producer, effects of aeration may start almost from the moment the clinker is discharged from the kiln and continue through grinding, storage, and discharge of the cement from the silo into either bags or bulk transportation equipment. From the standpoint of the user, the effects of aeration may be causing changes in the stiffening characteristics of his cement during transport from the mill to the job, during transfer from the transport to storage on the job site, and during transfer from storage to the mixer. The aeration that occurs during storage and packing at the plant and during transport to the job site and transfer to storage and mixer at the job site might be classed as normal aeration, except in cases where cements may be stored for excessively long periods of time at the job site.

There have been many cases reported in which cement tested as it entered the silo at the plant showed normal set but showed rapid set as discharged from the silo. It appears very likely that almost all, if not all, of this development of rapid set is the result of dehydration of gypsum in the silo and is not related in any significant degree to aeration of the cement. On the other hand, some cements, when discharged from the silo, show normal set but develop rapid set during handling and storage subsequent to discharge from the silo. This is the result of aeration, and it is believed that it occurs largely, if not entirely, in cements that contain large amounts of hemihydrate and relatively large amounts of C_3A. Such cements, when first ground, can react with SO_3 at very high rates and, accordingly, the hemihydrate is not given an opportunity to crystallize as gypsum in the cement paste. Aeration decreases the reactivity of the C_3A temporarily when the C_3A is mixed with water, and this permits crystallization of gypsum in the cement paste. Hence, these cements have developed true false set upon aeration.

X-Ray Diffraction Methods

It is possible by the use of X-ray diffraction techniques to determine the presence of the various forms of calcium sulfate in cements if they are present in excess of certain small amounts. This method has been used for this purpose in a number of laboratories and has demonstrated the presence of hemihydrate as well as the absence of gypsum in many commercial cements. This technique can also be used to study the rates of the reactions of the cement minerals with water. Yamaguchi, et al, (4), used this method to demonstrate that C_4AF reacts very rapidly with water during the first few minutes after the paste is made.

It appears that the over-all rate at which C_4AF reacts in cement pastes is much slower than that for C_3A. However, this does not mean that C_4AF crystals cannot react at a very rapid rate until their surfaces are covered with reaction products. It appears reasonable to believe that such a very rapid initial reaction could contribute quick-stiffening characteristics to pastes made with cements that contain their alumina largely in the form of C_4AF with very little, if any, of it as C_3A. It should be remembered that we are talking about quick-stiffening characteristics that almost certainly would not be detected if longer mixing times and higher water-cement ratios were used in Method C 359. These may be stiffening characteristics that have no meaning from the standpoint of performance of the cement on the job but do have meaning to the investigator who is attempting to determine the fundamental reactions of false and quick set.

TABLE III.—DATA FOR COMMERCIAL CEMENT NO. 1.

Treatment of Cement	Shaking Time, min	Composition of Extract, *M*					
		SO_3	$(OH)_2$	CaO	Na_2O	Saturated SO_3	Excess SO_3
As Received	1	0.025	0.028	0.029	0.024	0.021	0.004
	3	0.016	0.043	0.028	0.031	0.025	−0.009
Aerated 24 hr	1	0.052	0.024	0.059	0.017	0.019	0.033
	3	0.040	0.024	0.046	0.018	0.020	0.020
Aerated 48 hr	1	0.053	0.023	0.062	0.014	0.018	0.035
	3	0.043	0.023	0.051	0.015	0.018	0.025

Tests with Aerated Cements

As pointed out earlier, some cements develop rapid-stiffening characteristics when aerated. This behavior suggested that something besides dehydrated gypsum was responsible for false set, at least with certain cements. After many attempts to obtain data to show what was happening during aeration, these efforts (5) were rewarded with the results shown in Table III in extraction tests with a commercial cement ground with a mixture of 60 per cent natural anhydrite and 40 per cent gypsum to give an SO_3 content of about 2.5 per cent.

In this test, 200 g of cement were shaken with 150 ml of water for 1- and 3-min periods, and the extracts were analyzed for SO_3, $(OH)_2$, and CaO. The alkali content (Na_2O+K_2O) expressed as Na_2O was calculated by the equation, moles SO_3 + moles $(OH)_2$ − moles CaO = moles Na_2O. In Table III the values in the column headed "Saturated SO_3" are the moles of SO_3 required to saturate a solution with gypsum when the alkali content of the solution is that shown in the column headed "Na_2O." The values in the last column indicate the degree to which the solution is supersaturated or undersaturated with respect to gypsum. Examination of the data for the cement as received shows that the extract at 1 min contained 0.004 moles SO_3 in excess of the amount required by the saturated solution. Broken crystals and very small crystals of any material such as gypsum usually yield solutions that are slightly supersaturated with respect to perfect and larger crystals. Hence, slight supersaturations with respect to gypsum would be normal for extracts from portland cement pastes. Therefore, the slight supersaturation in the extract of the cement as received does not necessarily indicate the presence of dehydrated gypsum in this cement.

When the cement was aerated for 24 hr, the SO_3 content of the 1-min extract was 0.033 mole in excess of that required for saturation with respect to gypsum. This supersaturation could occur only if the original cement contained dehydrated gypsum. One conclusion, therefore, was that the unaerated cement contained dehydrated gypsum and that C_3A reacted with SO_3 at a rate sufficient to prevent the dehydrated gypsum from producing a highly supersaturated solution. The data for the 3-min extracts from the unaerated cement show this extract to be undersaturated to the extent of 0.009 mole SO_3. This substantiates the conclusion that the C_3A was reacting with SO_3 very rapidly in the unaerated cement. Tests made with calcium chloride indicate that certain cements could combine with as much as 0.75 per cent SO_3 during the first 1 or 2 min of contact with water

Since the aerated sample produced solutions that were supersaturated with respect to gypsum, it had to be concluded that aeration had in some way decreased the rate at which C_3A combined with SO_3, and tests with calcium chloride showed that aeration decreased the rate at which C_3A combined with calcium chloride. False-set tests with Method C 359 showed the original cement to have no rapid-stiffening tendencies, whereas they showed the

aerated sample to be rapid-stiffening. This led to the conclusion that cements that did not show false set until after aeration were cements that contained dehydrated gypsum but which also contained sufficient quantities of C_3A to react at high enough rates with SO_3 to prevent the dehydrated gypsum from producing solutions highly supersaturated with respect to gypsum. A cement with this quantity of dehydrated gypsum but a smaller amount of C_3A probably would almost certainly have shown false set without aeration.

Following the report of this work, Swayze (6) presented data that showed that a clinker which theoretically contained zero C_3A and only traces of alkalies and SO_3 could be ground without calcium sulfate to a cement that showed no rapid stiffening by Method C 359. However, aeration caused this product to yield a mortar that stiffened rapidly but which liberated very little heat and in which the workability was restored by remixing. This behavior did not agree with the usual definition of quick set. Also, the stiffening could not have been caused by precipitation of gypsum and, accordingly, was not the usual false set. This clinker, when ground with gypsum, did not show stiffening by Method C 359 until aerated. The aerated samples generally gave initial and remix penetrations of 50 mm and intermediate penetrations of 3 to 0 mm.

This posed a new problem in the overall problem of rapid stiffening and efforts were made to obtain data to demonstrate what occurs in pastes made with unaerated and aerated cements that do not contain dehydrated gypsum. In this study (1), a clinker was ground with 2.0 per cent water plus 2.0 per cent SO_3 as natural anhydrite and tested by Method C 359 (see Table IV).

These results suggested that the quick setting of the original cement occurred because the natural anhydrite could not dissolve rapidly enough to control the reactions of C_3A with water. If this reasoning was correct, the addition of a small amount of hemihydrate which dissolves rapidly would eliminate the quick stiffening, and the addition of 0.5 per cent SO_3 as hemihydrate had that effect.

Aeration accentuated the quick-setting tendencies. This seemed to be the opposite of what had been obtained before, where aeration appeared to decrease the rate at which C_3A reacted with water.

The next experiment that shed light on this problem was made with another cement ground with natural anhydrite (see Table V). These data show that, in the mortar made with the unaerated cement, the natural anhydrite dissolved at a rate sufficient to maintain the liquid phase saturated with respect to gypsum. They also show that, in the aerated sample, the liquid phase was almost devoid of both SO_3 and CaO. That is, the liquid phase was practically a solution of alkali hydroxides. When 0.5 per cent SO_3 as hemihydrate was added to the aerated sample, the liquid phase at 1 and 3 min was highly supersaturated with respect to gypsum. The unaerated sample would be classified as normal-setting, the aerated sample as quick-setting, and the aerated sample with added hemihydrate as mildly false-setting.

TABLE IV.—DATA FOR EXPERIMENTAL CEMENT NO. 1.

Cement	Penetration, mm				
	Initial	5 min	8 min	11 min	Remix
As ground	40	9	3	2	6
+0.5 per cent SO_3 as hemihydrate	50+	50+	50+	50+	50+
Aerated 48 hr	Mortar was crumbly in mixer; temperature rose to 84 F.				

TABLE V.—DATA FOR EXPERIMENTAL CEMENT NO. 2.

Cement	Penetration, mm					Shaking Time, min	Composition of Extract, *M*			
	Initial	5 min	8 min	11 min	Remix		SO_3[b]	$(OH)_2$	CaO	Na_2O
As ground	50+	50+	50+	50+	50+	1	0.018	0.022	0.023	0.017
						3	0.017	0.023	0.022	0.018
Aerated 48 hr	50+	0	0	0	0	1	0.009	0.013	0.007	0.015
						3	0.001	0.020	0.002	0.019
Aerated +0.5 per cent SO_3[a]	50+	43	34	20	50+	1	0.044	0.014	0.050	0.009
						3	0.042	0.012	0.042	0.011

[a] SO_3 as hemihydrate.
[b] SO_3 at equilibrium 0.015 to 0.018 *M*.

A study of these data substantiates the theory advanced in 1934 by Roller (7) to the effect that quick set caused by C_3A is prevented when the liquid phase contains sufficient $Ca(OH)_2$ to convert the surfaces of the C_3A crystals to hydrated C_4A and that the purpose of the added calcium sulfate is to transform to $Ca(OH)_2$ the alkali hydroxides released by the cement minerals. The early work on C_3A by Bates (8) indicated that $Ca(OH)_2$ was necessary for the control of the setting of this compound.

The results of these experiments on aeration lead to the conclusion that the cement minerals chemisorb H_2O and CO_2 from the air and become covered with reaction products that interfere with reaction of the cement minerals with water. The principal source of $Ca(OH)_2$ in the liquid phase of a cement paste is the C_3S which probably reacts as follows with the water in a cement paste:

$$(3CaO \cdot SiO_2) + \text{Water} = 3CaO \cdot 2SiO_2 \cdot 3H_2O + 3Ca(OH)_2 \quad (2)$$

Manabe (1) found that aeration temporarily decreased the rate of combination of SO_3 with cements.

These results, together with those of Yamaguchi, et al (4) that showed that C_4AF reacts rapidly with water and that C_3S retards the rate of this reaction, appear to explain the results obtained by Swayze with his zero C_3A clinker. In the mortar made with the freshly ground clinker, the C_3S was able to release $Ca(OH)_2$ at a rate sufficient to prevent the C_4AF from producing quick set. Chemisorption of H_2O and CO_2 by the C_3S during aeration decreased the rate at which it released $Ca(OH)_2$ to a degree that permitted the C_4AF to produce mild quick setting. Since this clinker contained almost no alkalies, the addition of calcium sulfate could not contribute any $Ca(OH)_2$ to the solution. Hence, the addition of calcium sulfate to such a clinker should have no value in preventing quick set unless it accelerates the rate at which other cement minerals, such as C_3S, release $Ca(OH)_2$. Swayze found that this clinker, when ground with gypsum, became quick setting on aeration just as it did when ground without gypsum.

The clinker from which experimental cements No. 1 and 2 were made contained approximately 12 per cent C_3A and 8 per cent C_4AF by the usual calculations for compound composition. These cements developed quick set in Method C 359 that could not be destroyed by reworking. The clinker used by Swayze with zero C_3A when ground without gypsum and aerated showed zero penetrations in Method C 359, but the workability of the mortar appeared to be completely restored by remixing. These results indicate that C_4AF reacts sufficiently to cause rather severe stiffening in the mortar used in Method C 359, but that the stiffening is a type that is readily destroyed by remixing. This suggests that the initial reaction of C_4AF and water is probably only sufficient to coat the crystals with a protective layer of reaction product, whereas the initial reaction of C_3A and water does not stop at a surface coating when there is insufficient $Ca(OH)_2$ available to form a layer of hydrated C_4A on the crystals of C_3A. It appears, therefore, that cements with low C_3A

contents probably will never develop sufficient quick set under any condition, low SO_3 content, aeration, etc., to cause trouble in service. However, such cements would be expected to develop severe false set if they contained more than about 0.5 per cent SO_3 as hemihydrate, whereas cements with relatively high C_3A contents could contain much more SO_3 as hemihydrate without showing severe false set unless aerated sufficiently to reduce markedly the rate at which C_3A combines with calcium sulfate.

The data in Table V demonstrate the difficulty of obtaining data that will clearly define the reactions involved in quick setting. Data from extraction tests demonstrate that the liquid phase of a cement paste that shows quick setting is highly unsaturated with respect to gypsum at 3 and usually at 1 min. The data in Table V show that the natural anhydrite in the unaerated sample was able to dissolve at a rate at which the solution was saturated with respect to gypsum at 3 min. If one assumed that the Na_2O in these extracts existed as NaOH, then, in the 1-min extract of the original cement there would be 0.005 mole of $(OH)_2$ to combine with CaO, and in the 1-min extract of the aerated sample there would be a deficiency of 0.002 mole of $(OH)_2$.

It seems evident from these results that the rates of reaction of C_3A and C_4AF with water have to be retarded within the first 1 min of contact with water if quick setting of some degree is to be avoided. Since there appears to be no reason to expect that aeration can decrease the rate at which anhydrite dissolves, and since the data from extraction tests indicate the extract from the aerated sample to be deficient in $Ca(OH)_2$, it appears that C_3A and C_4AF react extremely rapidly with both $Ca(OH)_2$ and $CaSO_4$ during the first minute.

It has been demonstrated that aeration can decrease the rates at which cements combine with $CaSO_4$ and $CaCl_2$. This indicates that chemisorption of either H_2O or CO_2 or both decreases the reactivity of C_3A and C_4AF. It seems reasonable, therefore, to conclude that chemisorption of either H_2O or CO_2 or both by C_3S and C_2S would decrease the rates at which these compounds would hydrolyze and release $Ca(OH)_2$ to the liquid phase of the cement paste.

In addition to $Ca(OH)_2$ obtained from the hydrolysis of C_3S, C_3A, and C_2S, the liquid phase can obtain $Ca(OH)_2$ by the interaction of $CaSO_4$ with any KOH and NaOH that is released to it from the alkali-bearing minerals. The data in Tables III and V show that aeration decreased the rates at which alkalies entered the liquid phase. The alkalies that could enter the liquid phase as KOH and NaOH probably are present in solid solution in the calcium silicates and aluminates. Hence, if aeration decreases the rates at which the silicates and aluminates hydrolyze, it should decrease the rates at which both $Ca(OH)_2$ and alkali hydroxides enter the liquid phase.

From this, it appears that, unless C_3A and C_4AF can chemisorb relatively large amounts of $Ca(OH)_2$ almost immediately on contact with water, they will cause the cement paste to be quick-setting. It seems that there can be no question about this being a reaction in which the $Ca(OH)_2$ in solution reacts directly with the surfaces of the C_3A and C_4AF crystals as postulated by Roller. This reaction appears not to deactivate the C_3A and C_4AF completely against reaction with $CaSO_4$ because, in a normal setting cement, considerable amounts of SO_3 are combined within a few minutes. It is known from the work by Lerch, Ashton, and Bogue (9) that C_3A and $CaSO_4$ will not react to form sulfoaluminates except in solutions that are saturated with $Ca(OH)_2$. Hence, in the absence of $Ca(OH)_2$ at the surfaces of the crystals of C_3A these crystals may not be able to form sulfoaluminate but, instead, react with water as follows:

$$3CaO \cdot Al_2O_3 + \text{Water} = 2CaO \cdot Al_2O_3 \cdot XH_2O + Ca(OH)_2 \quad \ldots\ldots(3)$$

It is known that, in the absence of $CaSO_4$ and $Ca(OH)_2$, crystals of C_3A react at an extremely rapid rate with water and become cemented together. It seems that Eq 3 must be the reaction that occurs when a cement becomes quick-setting.

It might be well to digress to point out that the data for these two experimental cements indicate that a producer should never use natural anhydrite alone as the modifier in some portland cements. The quick set developed in these experimental cements during aeration was severe enough to have made the cements too fast-setting for use on most jobs. Such severe quick-setting probably would not have been produced under normal aeration. However, there is always the chance that, under some conditions, abnormal aeration will occur.

It is now possible to explain rapid setting of cement pastes:

1. A cement paste will be quick-setting unless the C_3S and other minerals can release $Ca(OH)_2$ at a rate that will prevent the rapid reaction of C_3A and C_4AF with water. Calcium sulfate assists in the retardation of these reactions by supplying Ca^{++} ions to form $Ca(OH)_2$ with alkali hydroxides released from alkali-bearing minerals.

2. A cement paste will be false-setting if the cement contains dehydrated gypsum in an amount sufficient to permit crystallization of some quantity of gypsum. It is not possible to define either the amount of dehydrated gypsum or the quantity of recrystallized gypsum required to produce false set because of the many factors that are involved. Some of these factors are the quantities of C_3A and C_4AF in the clinker, the fineness of the cement, the temperature of the paste, and the period of mixing.

3. Cements that contain gypsum and little or no dehydrated gypsum may become quick-setting during aeration from chemisorption of H_2O and CO_2 by the C_3S which retards the rate at which this compound releases $Ca(OH)_2$ to the liquid phase.

4. Cements that contain dehydrated gypsum and are not false-setting may become false-setting when aerated from chemisorption of H_2O and CO_2 by the C_3A and C_4AF which decreases the initial rates at which these compounds combine with calcium sulfate.

The Role of Calcium Sulfate

Calcium sulfate appears to combine at a rapid rate in cements that have normal setting characteristics and, accordingly, appears to play a part in preventing severe quick set other than that of converting alkali hydroxide to $Ca(OH)_2$. It may be that much of this reaction with $CaSO_4$ occurs after the almost instantaneous reaction of C_3A and C_4AF with $Ca(OH)_2$ has occurred.

The data in Tables IV and V show that the two cements ground with natural anhydrite showed severe quick-setting, and the extraction data of Table V indicate that the reason was that natural anhydrite could not dissolve at the rate at which SO_3 was being removed from the solution. This rapid combination of $CaSO_4$ had the effect of decreasing the $CaSO_4$ content of the liquid phase, but it also had the effect of decreasing the $Ca(OH)_2$ content. The addition of hemihydrate corrected both of these deficiencies, and it could be that it prevented the severe quick stiffening because it increased the concentration of $Ca(OH)_2$ and not because it increased the concentration of $CaSO_4$. It appears that none of the data show conclusively that the only role of $CaSO_4$ is to maintain a high concentration of $Ca(OH)_2$ in the liquid phase of the cement paste. On the other hand, it also appears that none of the data show that the $CaSO_4$ serves any other purpose.

It might be expected that one way to prevent quick set would be to add some calcium hydroxide to the cement. This has been tried without success. When calcium hydroxide is added to water, it enters the solution by a normal solution process, which is a relatively slow process. When highly unstable compounds, such as C_3S and C_3A, come in contact with water, they tend to react violently with water until their surfaces

have been (to some degree) deactivated by a coating of reaction products. In this reaction, C_3S probably splits off $Ca(OH)_2$ at many times the rate at which crystals of $Ca(OH)_2$ dissolve.

Cement particles are to a large extent agglomerates of crystals of the cement minerals. Hence, when water attacks the surfaces of the C_3S crystals in such an agglomerate, the $Ca(OH)_2$ that is released is immediately available to react with the adjoining crystals of C_3A. It is not difficult to visualize that the approximately 50 to 75 per cent of C_3S in a cement could easily release sufficient $Ca(OH)_2$ to form hydrated C_4A on the surfaces of the approximately 15 to 25 per cent of $C_3A + C_4AF$ in the cement. It also is not difficult to visualize that chemisorption of H_2O and CO_2 by the crystals of C_3S and C_3A could markedly reduce the rates at which these crystals react with water.

Practical Applications

It is now recognized that calcium sulfate is a necessary ingredient in cement from the standpoint of developing strength and of producing cement products with relatively low-shrinkage characteristics. So far, no other material has been found that can be substituted for calcium sulfate for these purposes.

It is well known that gypsum loses water to form hemihydrate at relatively low temperatures in atmospheres of relatively low humidity. The rate at which this reaction occurs is accelerated both by increasing temperature and by decreasing the relative humidity. It is, therefore, impossible to predict the degree to which the gypsum will be dehydrated in any milling circuit. However, it seems very likely that some dehydration occurs in every commercial milling circuit. Also, dehydration can occur during storage of the cement. The amount of dehydration that occurs during storage will be a function of the temperature of the cement and the length of the period of storage. It is conceivable that cement stored at relatively low temperatures might have most or all of the gypsum dehydrated if stored for very long periods of time.

The ideal grinding circuit (from the standpoint of preventing dehydration of the gypsum) should be a short mill in closed circuit with an air separator followed by a cement cooler. A cement ground in such a circuit with gypsum and discharged from the cooler at 120 F gave the results shown in Table VI. It appears from these results that this cement tended to develop mild quick-setting tendencies during storage. This stiffening must not have been false set, because the addition of 0.5 per cent SO_3 as hemihydrate decreased the stiffening instead of augmenting it, and X-ray diffraction studies on this cement

TABLE VI.—DATA FOR COMMERCIAL CEMENT NO. 2.

Treatment	Penetration, mm (Method C 359)				
	Initial	5 min	8 min	11 min	Remix
A....As received.....	50+	50+	50+	50+	50+
B....Stored 10 weeks in a sealed can....	50+	45	38	22	50+
C....B + 0.50 per cent SO_3 as hemihydrate	50+	46	45	36	50+
D....B + 0.50 per cent $CaCl_2$.....	50+	50+	44	36	50+
E....B aerated 24 hr.....	45	42	32	16	50+

gave positive results for the presence of gypsum and negative results for the presence of hemihydrate. Aeration for 24 hr after the 10 weeks storage increased the quick setting slightly.

The results of this study indicate that cements ground with gypsum under conditions that would dehydrate little, if any, of the gypsum and also stored under conditions that would dehydrate little, if any, of the gypsum are not likely to develop more than mild quick-setting tendencies when aerated to the extent that is normal for the usual packing and handling of cement. It seems, therefore, that, when severe rapid-stiffening tendencies develop during normal aeration, the cement contains sufficient dehydrated gypsum to produce false set. This leads to the conclusion that most if not all, of the rapid stiffening which develops in cements during packing, handling, and storage subsequent to packing is false set produced by dehydrated gypsum in the cement and that false set develops because the reactivity of C_3A and C_4AF toward SO_3 is reduced during these operations by chemisorption of H_2O and CO_2. In other words, if manufacturers produce cements with relatively low contents of hemihydrate, there probably will be no problem with respect to the development of rapid-stiffening characteristics that are now produced by aeration.

It should be pointed out that the mild quick-set shown by Method C 359 for commercial cement No. 2 might not have been observed if the mortar had been made with 32 instead of 30 per cent water, because it has been observed in similar studies that additional water is very effective in eliminating mild stiffening in this test. Perhaps a change in Method C 359 to permit the use of 32 per cent water with cements in the fineness range of type I cements and 34 per cent for cements in the fineness range of type III cements would give a method that would show little or no stiffening for all cements except those that show moderately to severe false and quick setting. Then the ability or lack of ability to restore workability during remixing probably would distinguish false-setting from quick-setting cements.

Nature of Dehydrated Gypsum

As stated earlier, gypsum can be dehydrated to either hemihydrate ($CaSO_4 \cdot \frac{1}{2}H_2O$) or soluble anhydrite ($CaSO_4$). It has become rather common practice in discussing portland cements to refer to dehydrated gypsum with the idea that this term does not specify whether the dehydration has stopped at the hemihydrate stage or gone to the soluble anhydrite stage. Results of recent work by Razouk, Salem, and Mikhail (10) show that soluble anhydrite takes up very quickly sufficient water vapor to form hemihydrate in atmospheres of very low vapor pressure. Hence, it appears that any soluble anhydrite formed in the mill would be converted immediately to hemihydrate when the cement was discharged from the mill into colder air which always carries some water vapor. It should, therefore, be safe to speak of hemihydrate in cement instead of using the expression "dehydrated gypsum."

These investigators also found that hemihydrate absorbed water at an extremely slow rate until the relative humidity of the atmosphere was almost 100 per cent. This leads to the conclusion that hemihydrate in cement would never be converted to gypsum during the usual handling and storage of the cement. This is important from the standpoint of the presence of gypsum crystals to act as nuclei for the crystallization of gypsum. If all of the gypsum was converted to hemihydrate during grinding and storage, the paste would not initially contain such nuclei because gypsum crystals would not be formed during the handling and storage of the cement.

Summary

This paper attempts to present the story of quick and false set in a usable form to the producers and users of cement. There appear to be few, if any, who disagree with the conclusion that hemihydrate is responsible for false set. The problem of the producer in eliminating false set from his cement is to be certain that the quantity of hemihydrate in its does not exceed approximately the amount that can combine with the C_3A and C_4AF during the mixing period. For typical types I and III cements, this probably is of the order of 1.0 per cent SO_3 and of the order of 0.5 per cent SO_3 for types II, IV, and V cements. This could be accomplished by grinding with blends of gypsum and natural anhydrite in which the gypsum content plus the SO_3 content of the clinker did not exceed

these values for SO_3 in the cement. This would permit dehydration of all of the gypsum during grinding and storage.

Another way would be to use gypsum and cool the cement as discharged from the mill to a temperature at which gypsum dehydrates very slowly. This assumes that some hemihydrate may be formed in the mill but not to a very great extent.

There is danger that severe aeration would cause the above cements to become false-setting. However, it seems unlikely that false setting would develop under the normal operations of packing and handling. If the blend of clinker and gypsum is ground and stored under conditions in which very little or none of the gypsum is dehydrated, the cement might develop mild quick set during packing and handling. However, it seems that this quick set would rarely, if ever, be serious enough to be observed in practice. The same would be true for a cement ground with all anhydrite. However, in this case, there might be cases in which the quick set would cause trouble in practice because of the slow rate of solution of natural anhydrite.

It seems that the producer is now equipped with the necessary knowledge and testing methods to be able to produce cements that will neither have severe quick-setting nor severe false-setting tendencies when properly handled on the job. There is no evidence in any of this work that small amounts of hemihydrate would be harmful, and there is evidence that small amounts might eliminate the danger of quick set developing during handling of the cement.

Conclusions

False set results only from the crystallazation of gypsum in the cement paste. This crystallization can occur when some quantity, which varies with different clinkers, of calcium sulfate hemihydrate is added to the cement or is formed either during grinding or storage of the cement and possibly when the clinker contains relatively large amounts of alkali sulfates.

Quick set results from the reactions of C_3A and C_4AF with water and may vary from mild to severe. It appears that C_3A is the only compound in portland cement that can produce quick set of a severity sufficient to cause difficulty in the usual operations of placing and finishing. C_4AF can cause a mild degree of quick set, but this is readily destroyed by working and should, it seems never be observed in practice in the field.

References

(1) *Proceedings*, Fourth International Symposium on the Chemistry of Cement, Washington, D. C. (1960).

(2) Richard K. Meade, "Portland Cement," The Chemical Publishing Co., Easton, Pa., pp. 603–604 (1926).

(3) W. C. Hansen and E. E. Pressler, "Solubility of $Ca(OH)_2$ and $CaSO_4 \cdot 2H_2O$ in Dilute Alkali Solutions," *Industrial and Engineering Chemistry*, Vol. 39, p. 1280 (1947).

(4) Goro Yamaguchi, Kumihiro Takamoto, Hiroshi Uchikawa, and Shigehide Tagi, "X-Ray Researches on the Influence of Gypsum Upon Rate of Hydration of Portland Cement Compounds," *Semento Gijutsu Nenpo*, Vol. XIII, pp. 62–73 (1959).

(5) W. C. Hansen, "Aeration Cause of False Set in Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 58, p. 1044 (1958).

(6) Myron A. Swayze, Discussion of paper by W. C. Hansen, "Aeration Cause of False Set in Portland Cement," *Ibid.*, p. 1050.

(7) Paul S. Roller, "The Setting of Portland Cement—Chemical Reactions and Role of Calcium Sulfate," *Industrial and Engineering Chemistry*, Vol. 26, pp. 669–677 (1934).

(8) P. H. Bates, "Cementing Qualities of Calcium Aluminates," *Technical Paper No. 197*, Nat. Bureau of Standards (1921).

(9) W. Lerch, F. W. Ashton, and R. H. Bogue, "The Sulfoaluminates of Calcium," *Journal of Research*, Nat. Bureau of Standards, Vol. 54, pp. 715–731 (1929).

(10) R. I. Razouk, A. Sh. Salem, and R. Sh. Mikhail, "The Sorption of Water Vapor on Dehydrated Gypsum," *Journal of Physical Chemistry*, Vol. 64, pp. 1350–1355 (1960).

Discussion of a Paper on Workability of Masonry Mortars[1]

MR. J. G. DEMPSEY.[2]—In this most interesting paper, the author raises several points that deserve clarification. First, it is true that workability is a very important property in masonry mortar. Masons in this area find it so, and when given the opportunity reject combinations of ground limestone, cement and an air-entraining agent in favor of cement and lime combinations. On the same basis, the 1:1:6 proportions quoted in the article are considered by the writer to be quite harsh. A 1:2:6 proportion is better.

Another point that must be considered before using the entrained air contents noted of 16 to 25 per cent is bond, or adhesion of the mortar to the brick or other unit. Tests have shown that when air content of a mortar exceeds about 13 per cent, bond is significantly reduced.

Tensile strength in the mortar deserves careful attention also. A series of similar mortars tested in this area gave results of interest in this connection (see Table I).

The adhesion test described appears to have merit, although a glass ball in place of a 1-in. wire ring would seem to give a better approximation of the surface adhesive quality to be evaluated. With the relatively small surface area of a ring, water surface tension might well replace the quality sought when an over-wet harsh mix is tested, and the point at which this shift occurs should be checked before giving undue weight to test values obtained with the ring.

The use of the modified Vicat apparatus to measure penetrability would appear to be a valuable additional measuring tool for measuring mortar characteristics. It is not clear whether the $\frac{3}{4}$-in. diam by $1\frac{3}{4}$-in. aluminum cylinder used is closed or open where in contact with the specimen. To get the consistency of a sample to react suitably

TABLE I.—TENSILE STRENGTHS OF VARIOUS MORTARS.

Mix	Type of Mortar	Water, per cent	Weight, lb per cu ft	28-Day Tensile Strength, psi
1:3.....	Cement	60	130	555
1:1:6.....	Cement-lime	100	124	150
1:2:6.....	Cement-lime	81	125	165
1:3.....	Masonry cement A	83	114	140
1:3.....	Masonry cement B	65	119	135

[1] L. Kampf, "Workability of Masonry Mortars," *Materials Research & Standards*, (formerly ASTM BULLETIN), Vol. 1, No. 1, Jan., 1961, p. 7.

[2] Director of Engineering, Robert L. Novak & Co., Des Plaines, Ill.

with the apparatus, a closed end similar to that of the modified Vicat used in ASTM Methods C 110 – 58 Section 5(*a*) would seem necessary.

That the tests set forth in the paper indicated that increasing air content is reflected in increasing workability and penetrability is not surprising, but the deleterious effects of excessive air content on bond and tensile strength have not been given their proper weight. It is to be hoped that there will be further investigations made, taking advantage of the fresh approach to mortar characteristics outlined. More tests and further consideration of service qualities of a mortar are needed before any firm order of performance as between cement, masonry cement, and lime are set up. If the paper is intended to emphasize the value of a particular admixture, as might be inferred, then the data are most inadequate. The writer assumes that such is not the case.

MR. L. E. HALSTED.[3]—Mr. Kampf's paper on "Workability of Masonry Mortars" is somewhat incomplete and therefore, it could be misleading. If taken literally and if we accept his premises, his paper would indicate that the use of a 1:6 mix of portland cement plus 1 per cent X-lime would produce an ideal masonry cement. While this material does entrain very large amounts of air, and air is a good workability agent, this is only one factor in the complex make-up of a satisfactory masonry cement.

We agree that good workability is a necessary and desirable characteristic of any good masonry cement. If workability were the only requirement of a masonry cement, then securing it by the use of excessively high air entrainment would indeed be a simple solution. But other properties such as bond strength and, to a lesser degree, compressive strength are examples of other essential factors, and many other properties could be cited.

Bond strength is greatly reduced with increased air entrainment, and in fact, bond can be almost completely destroyed with air contents exceeding 25 per cent. The advantages of good bond are obvious and any mortar that lacks good bonding properties should be questioned.

Mr. Kampf's paper does provide some points that are interesting. His definitions of the six factors controlling workability are not necessarily all related to workability. For example, we do not question his analysis of weight, but it has no bearing on workability of mortars as such. The fact that a workman may be required to handle heavier mortar is insignificant if the end product made with a lightweight mortar is inferior.

The author uses the expression, "time of set," which is contrary to the normal usage of this term; "rate of stiffening" would be more acceptable.

We agree with Mr. Kampf that the flow table is a crude measure of consistency. As he also pointed out, it is well known that the penetration method is a much more sensitive instrument. Since the Vicat apparatus also measures consistency, we can see no reason to use the flow table for mortars of this type. (It is satisfactory for nonair-entrained portland cement mortars.)

The adhesion test is an interesting one and the author is to be commended on his application of known methods to make a simple test.

The data in Table II of the paper are questioned because the author used different flows which could greatly influence the adhesion. More important is the fact that the flow table does not really measure consistency of these types of mortars due to their varying cohesivenesses. A much more accurate appraisal of relative adhesion would be found by using a uniform penetration value rather than a flow.

Since it is desirable to measure adhesion, it is suggested that uniform penetrations of the various mortars be obtained and that the penetrations should be equal after the test for adhesion is made. If these conditions are obtained, the effect of the mortar stiffening is eliminated. Another factor which could affect the adhesion test is bleeding or water gain. This is an important consideration since entrained air reduces, or in many cases, eliminates bleeding altogether.

TABLE II.—PERMEABILITY OF BRICK BOXES.

Mortar →	Cement-Lime	Masonry Cement	Cement
Proportion, volume	1:1:6	1:3	1:6 (plus additive)
Per cent air	4	19	25
Drop in Water Level After Aging One Month, in.			
Time, hr			
1	5.0	8	4.0
3	7.5	12	5.0
5	8.5	14	6.25
7	9.5	15	7.5
Drop in Water Level After Aging Six Months, in.			
1	1.75	2.75	1.50
3	3.25	5.50	2.50
5	3.75	6.50	3.25
7	4.25	7.00	4.00

The reduction in permeability between the six-month and the one-month test was apparently due to the efflorescent material depositing in some of the leaks. These boxes are pictured in a previous paper on efflorescence.[3c]

In determining even relative workability of masonry mortars, a slight change in consistency will greatly vary the results. This applies to the adhesion test as well as many other tests.

FRANCIS J. MARDULIER.[3a]—Because the Subcommittee on Bleeding, Plasticity, and Workability of ASTM Committee C-1 on Cement has been asked to devise a method of test for evaluating the plasticity- or workability-producing characteristics of portland and masonry cements, I have distributed the author's paper to the members of this subcommittee.

Like Mr. Kampf, the subcommittee has concluded that the measurement of plasticity or workability involves many factors; hence, one simple test will not do. A penetration test has been of considerable interest, the problem being to agree on the most suitable of those methods which have been developed and tried. Mr. Kampf's adaptation of the Vicat penetration test has considerable merit because of its simplicity and the availability of the basic equipment in all cement-testing laboratories.

A. D. Conrow, a former member of the subcommittee but now retired, published a paper in 1959[3b] on a modification of the flow table, which uses rate of change of flow with drops of the flow table as a measure of plasticity, rather than the absolute flow value at any particular number of drops. The latter is used only as a measure of consistency. In view of the author's efforts along these lines, I would appreciate any comments he might care to make concerning the Conrow method.

MR. L. KAMPF (*author*).—Mr. Dempsey states "... the 1:1:6 proportions quoted in the article are deemed quite harsh and a 1:2:6 proportion is considered more favorably." I do not disagree with him. However, the New York City building code states "Cement-lime mortar shall be composed of one part cement, one part lime putty or

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[3b] A. D. Conrow, "An Approach to the Problem of Evaluation of Plasticity and Workability of Pastes and Mortars," *Proceedings*, Am. Soc. Testing Mats., Vol. 59, p. 1075 (1959).

[3c] Leo Kampf, "Discussion of Paper on a Method of Test for Potential Efflorescence of Masonry Mortar," ASTM BULLETIN, No. 240, Sept., 1959, p. 45.

hydrated lime and a maximum of six parts of sand." In ASTM Tentative Specification for Mortar for Unit Masonry (C 270),[4] type N mortar provides for 1 part cement, $\frac{1}{2}$ to $1\frac{1}{4}$ hydrated lime or lime putty, and sand equal to $2\frac{1}{4}$ to 3 times the sum of the volumes of cement and lime. The 1:2:6 mix is not provided for in either of these.

He states that "Tests have shown that when air content of a mortar exceeds about 13 per cent, bond is significantly reduced." Since ASTM Specification for Masonry Cement (C 91)[5] requires a minimum of 12 per cent air and since most masonry cements entrain about 18 per cent, this would mean that all masonry constructed with these cements would have their brick bonds seriously reduced with resultant leakage and structural impairment. This is contrary to experience. A review of the literature does not bear out this statement. The work of Watstein and Seese,[6] Thornton[7] or Pearson[8] do not indicate any such detrimental effect of air. Fishburn[9] shows that the most important factors are workmanship and brick suction. It follows therefore that workability and water retention are important properties in brick bond.

I had hoped to present a paper in the near future on factors affecting brick bond. I have used brick boxes and cross brick couplets to measure these factors.

The data in Table II from boxes built with a high-absorption common brick will give an indication of the effect of air. They were exposed outdoors for one month, filled with water and the drop in level determined at various intervals. The test was repeated after six months.

The cross-brick couplets gave similar results. These tests indicate one very important factor in brick bond. It is obtained in the first few minutes while the mortar is still plastic. If there is any movement of the brick after the mortar begins to stiffen, the bond will be lost. For example, if excessive pressure is used in tooling, the brick will be spread with a loss of bond. A workable mortar with a high water retention and a slower rate of stiffening reduces the chance of spreading the brick.

Mr. Dempsey's comments on the adhesion test has merit. The glass ball might give more indicative results. I have used a 1-in. brass plate. This gave higher tensions, though of the same relative values. I used the ring because this is a standard method of measuring surface tensions.

The $\frac{3}{4}$- by $1\frac{3}{4}$-in. aluminum cylinder was closed at the point of contact with the specimen. Variations in the use of the Vicat apparatus appear in various ASTM methods. ASTM Methods of Physical Testing of Quicklime and Hydrated Lime (C 110)[10] specifies a Vicat apparatus similar to what I described in my paper. However the dimensions are the same as those in ASTM Methods of Testing Gypsum and Gypsum Products (C 26).[11] I have since modified the Vicat penetration method by using a solid aluminum shaft $\frac{1}{2}$ in. in diam by $11\frac{3}{8}$ in. in length, weighing 100 g. This has extended the range of penetrations. Weights can be added to any desired amount. The penetration is proportional to the weight. The results are computed as the penetration per 100 g of weight.

I agree with Mr. Halsted that workability is not the only requirement of a masonry cement. Certainly bond strength is more important. It was beyond the scope of my paper to discuss all the "factors in the complex make-up of a satisfactory masonry cement." Workability, however, is a very important property in obtaining a good bond.

The statement that air contents in excess of 25 per cent can destroy the bond may be true with some mortars. As a generalization for all mortars it is not true. For example, a masonry cement may be formulated to give its optimum properties—water retention, strength, and workability—at 18 per cent. If this cement had its air content increased to 25 per cent, its strength would be so reduced that it would have little bond.

Mr. Halsted is correct in stating that "rate of stiffening" would be a more acceptable description of my data. This same criticism, however, would apply to any of the ASTM "time of set" tests, "initial set," "final set" for cements, plasters, etc. The test is empirical and the conditions are set arbitrarily.

The flow values in Table II of the paper varied between 103 and 109 per cent. I do not think this is an excessive variation. I do agree that using uniform penetration values rather than flow might give a more accurate appraisal.

In reply to Mr. Mardulier, I have done a considerable amount of work on workability using a modification of Conrow's procedure.

Conrow gives the potential energy, for a $\frac{1}{2}$-in. drop, as:

$$E = 1{,}27\ WN \ldots\ldots\ldots (1)$$

where:

W = weight of specimen, kg, and
N = number of drops

He then arbitrarily substitutes a value of 2 for the factor 1.27, giving

$$E = 2WN \ldots\ldots\ldots\ldots (2)$$

Equation 2 is therefore empirical, and, consequently, other conditions can be varied. I have substituted the standard truncated flow cone for the 4-in. hemisphere that Conrow used. In addition, I have found that Conrow's flow-measuring device is not essential. The flow table can be stopped at various intervals (I use 2, 5, 10, and 25 drops) and the flow measured. I have found that the flow measured after 25 drops in this manner will be within 2 per cent of the flow measured by continuously dropping the table 25 times.

Conrow's equation for the straight-line log-log plot of per cent flow, F, versus energy units, E, is $F = AE^b$. He states that "The constant A is related to ease of deformation, or consistency." He also states, "The constant b . . . is related to the rate of deformation with continued application of energy; its value is determined by the slope of the line. A steep slope or high value of b indicates a rapid spread of the specimen, thus indicating a mortar that easily falls apart—that has poor cohesion and plasticity, both of which are factors affecting workability."

This is essentially what I have attempted to show in my paper. Table

TABLE III.—COMPARISON OF FLOW-TABLE RESULTS WITH PENETRATION RESULTS.

Mix	Type of Mortar	Water, Per Cent	Air, Per Cent	Flow, Per Cent	A	b	Penetration, $\frac{1}{4}$-in. diam, 100 g, mm	Adhesion Tension, g
1:6	Cement	97	7.3	142	15.1	0.69	2.7	2.7
1:6	Lime	250	...	99	7.6	0.80	1.0	...
1:1:6	Cement-lime	105	...	100	10.0	0.72	5.5	...
		110	4.1	111	13.5	0.65	6.8	3.2
		115	4.1	127	18.5	0.62	13.2	...
1:3	Masonry	55	17.1	113	17.0	0.58	17.0	4.0
1:6	1 per cent additive	75	26.0	119	34.5	0.41	38.0	4.7

[4] 1959 Supplement to ASTM Book of Standards, Part 4, p. 61.
[5] 1960 Supplement to ASTM Book of Standards, Part 4, p. 15.
[6] David Watstein and Norman A. Seese, Jr., "Properties of Mortars of Several Compositions," ASTM BULLETIN, No. 147, Aug., 1947, p. 77.
[7] John C. Thornton, "Relation Between Bond and the Surface Physics of Masonry Units," *Journal*, Am. Ceramic Soc., Vol. 36, No. 4, April, 1953, p. 105.
[8] J. C. Pearson, "Measurement of Bond Between Bricks and Mortar," *Proceedings*, Am. Soc. Testing Mats., Vol. 43, p. 857 (1943).
[9] Cyrus C. Fishburn, "Water Permeability of Walls Built of Masonry Units," National Bureau of Standards, *Report BMS 82*.
[10] 1958 Book of ASTM Standards, Part 4, p. 249.
[11] 1960 Supplement to ASTM Book of Standards, Part 4, p. 43.

III shows the relation between Conrow's constants and mine. These represent the four mixes that I had described. The flow curves are plotted in Fig. 1.

I have since modified the penetration method by using a $\frac{1}{2}$ by $11\frac{3}{8}$-in. solid aluminum rod weighing 100 g. Additional weights can be added and the penetration computed as millimeters per 100 g. This has extended the range.

The data and the curve indicate the following:

1. The penetration test is related not only to the consistency but also to the cohesion or plasticity.
2. The adhesion tension is related to the cohesion or plasticity.
3. The flow curves indicate the weakness of the flow test.

At an energy unit of 1, or 1 drop of the table (Conrow's *A* value), large differences exist between the different mortars. These differences become much less at 25 drops; in fact, two sets of curves cross. In other words, mortars with high values at 1 drop give lower values at 25 drops. The reason for this is that cohesive, plastic mortars (high *b* values) do not flow as readily as granular mortars (low *b* values).

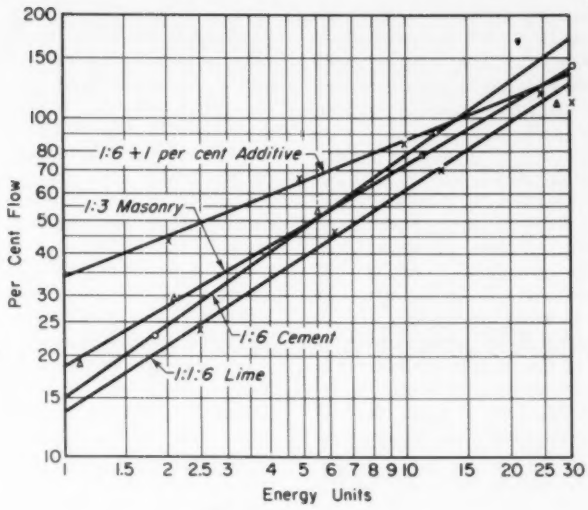


Fig. 1.—Flow curves.

Up to 10 drops the curve is a straight line. At 25 drops there is a deviation. This indicates that at 25 drops the flow table is not even a measure of consistency. At 10 drops it is a better measure of this. If it could be reduced further, it would give a better indication of this property.

Discussion of Paper on a Test Method for Air Entrainment of Standard Ottawa Sand[1]

MR. J. S. GRIFFITH.[2]—In the paper by DeFore and Corah, variabilities in air entraining cement tests are attributed to the 20–30 testing sand. Work at Armour Research Foundation, which has been assisting Ottawa Silica Co., Ottawa, Ill., in locating the cause of the variability, has confirmed many of the data reported in the paper as well as the interim treatment of covering the sand with tap water and drying at 75 C, or better, prior to use in air-entraining tests. However, new data have been developed which may be of value both to ASTM and the authors in furthering their research.

The authors state that "another series of tests indicated that the inorganic salts (in the tap water) themselves were probably not responsible for the air-entraining property of the sand." Since the data showed that repeated washing and drying increased the weight of the sand and that some of the best sands were obtained by covering with tap water and drying at 70 C, it was reasoned that time of exposure to the water, temperature during drying, and dissolved salts in the water all could be influencing factors.

As a first test of the reasoning, three samples split from a bag of sand were mixed with distilled and with tap water according to Federal Test Method SS-C-158:2401 P 5.2. Weights of sand were:

Weight of Sand, g per 400 ml.

Distilled Water	Tap Water
786.0	792.5
785.5	791.3
788.4	793.5
Avg.....786.6	792.4

The sand from each group of tests was immediately recombined, dried at 75 C, and mixed a second time with the same type of water. The distilled-water sample increased in weight to 793.3 g per 400 ml, while the tap-water sample increased to 797.0 g.

Duplicate experiments with sand from two different bags varied as to values at different stages of treatment, but all followed the same pattern. From this it is apparent that use of tap water rather than distilled water definitely produces greater weight per 400 ml and that either time of exposure or temperature or both are beneficial.

In an effort to evaluate the different factors, 10 samples were taken from a single bag, two of which were mixed with distilled water and tap water for use as controls. Of the others, three were covered with a given amount of distilled water and three with tap water. Two of these were dried at room temperature,

TABLE I.—EFFECT OF DRYING TREATMENT, WEIGHT IN G PER 400 ML.

	Covered with Distilled water	Covered with Tap Water	Dry
As received (control).....	...	...	787.0
Air dried.....	786.2	793.5	...
Dried at 55 C.....	788.2	791.0	785.1
Dried at 75 C.....	796.8	797.6	785.1

[1] "A Test Method for Air Entrainment of Standard Ottawa Sand," ASTM BULLETIN, No. 248, p. 48, (Sept., 1960).

[2] Supervisor, Geology and Clay Products, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

two at 55 C, and two at 75 C. The final two samples were placed dry in the oven so that they were exposed only to oven temperature. They were all mixed with distilled water so that all differences would be attributable to the drying treatments (Table I).

From this it is evident that heating to 75 C is of no value in itself. Furthermore, treatment with distilled water and drying either in air or at 55 C is of little benefit; however, drying at 75 C is definitely beneficial. Use of tap water again shows to advantage, but differences in water are of minor, if any, importance at 75 C. The conclusion that must be drawn is that whatever is causing the variation in weight is influenced by the type of water, time of exposure to the water, and temperature of drying.

Since it seemed improbable that the quartz grains themselves were influenced by these factors, then impurities not removed by the washing operation might be the cause of the erratic behavior. To test this theory, three 3000-g duplicate samples were placed in mill jars (without pebbles). One of these was covered with a liter of distilled water, one with tap water, and one was left dry. These were milled for ½ hr. The ones containing water were decanted, rinsed twice with their respective waters, air-dried, and mixed with distilled water. The resulting weights were:

As Received (control), g	785.6
Distilled wash, g	790.9
Tap wash, g	793.4
Milled (no wash), g	779.8

Since a previous experiment had shown that soaking in distilled water and drying in air caused little or no increase in weight, the difference here is attributed to washing. The sample milled in tap water again shows to advantage while the sample milled dry is very poor.

Of special interest was the wash water, which had been saved for analysis. The sediment in the distilled water remained in suspension for days, while that in the tap water settled in a matter of hours. X-ray analysis of these sediments showed them to consist of very fine quartz, kaolin, and, in the case of the sample washed in tap water, perhaps a trace of calcium carbonate. Grab samples taken from 10 different bags of sand and washed in the same way showed that the amount of material, while quite small, varied between 0.013 and 0.020 per cent by weight. However, this amounts to a difference of 50 per cent between the maximum and minimum. It is probable that all of the sediment was not removed from the samples, but, because they were all washed in the same way, the values can be used for comparison.

At this point it was beginning to appear as though the very small amount of sediment, probably the clay, was the cause of the erratic behavior of the sand, and it was reasoned that the sphere of the clay's influence about each sand grain could be restricted by use of either one or a combination of the ions present in tap water. To test this theory, selected salts were introduced into the distilled water with which the sand was treated. Since this work is not completed, it would not be worth-while to describe all of the work in detail. However, some of the results show the significance of the treatment.

In studying divalent versus trivalent ions, a sand was used which gave a weight of 784.5 g per 400 ml when mixed with distilled water and a weight of 786.1 g when dried at 75 C and remixed with distilled water. In making the test, the mixing water was placed in the mixing bowl and sufficient salt introduced to give 500 ppm of the oxide. When the salt was dissolved, or in the case of less soluble salts, dispersed, the sand was introduced and the usual mixing process followed. After the weight was taken the sand was recombined with the excess, dried, and remixed with distilled water. The results are shown in Table II.

TABLE II.—SAND TREATMENT WITH SALTS IN DISTILLED WATER, WEIGHT IN G PER 400 ML.

	First Mixing	Second Mixing
Control	784.5	786.1
$MgCO_3$	783.2	794.1
$Mg(NO_3)_2$	781.3	796.2
$Al_2O_3 \cdot H_2O$	779.4	790.0
$Al(NO_3)_3$	784.1	802.9

From these data it is apparent that: (1) little is accomplished by introducing the salts into the mixing water and that the sand must be at least heated and possibly dried before the treatment is effective; (2) the less-soluble magnesium carbonate and insoluble aluminum hydrate are less effective than the soluble nitrates; and (3) trivalent aluminum ions are more effective than divalent magnesium ions. Subsequent tests indicated that magnesium sulfate was more effective than the nitrate and that aluminum chloride also was more effective than the equivalent nitrate.

In the preceding study all samples were evaporated to dryness in their respective salt solutions. As this would be impractical in a commercial process, experiments were run in which the sand was placed on a screen, immersed in a solution for a given period of time, drained, dried at about 100 C, cooled, and mixed with distilled water. The salts studied to date are $MgSO_4$ (500 ppm) and $AlCl_3$ (333 ppm), and the time of immersion 1, 5, and 15 min. The results using a sand that gave a weight of 789.3 g after covering with distilled water, drying at 75 C, and mixing with distilled water were:

	Weight, g per 400 ml		
	1 min	5 min	15 min
$MgSO_4$	794.8	799.2	805.8
$AlCl_3$	806.3	807.3	806.8

It is notable that the magnesium salt treatment improves with increased time of immersion, while the aluminum salt is as effective for a 1-min as for a 15-min soak.

For what it may be worth, it has been noted that treatment with different salts even influences the packing of dry sand. The values given below are for 400 ml of the sand treated with the indicated salt.

	Weight, g per 400 ml
$FeSO_4$	605.1
$MgSO_4$	612.1
NaCl	612.2
$AlCl_3$	618.9

At the present stage of the research it appears that both the clay retained by the sand and the salts dissolved in the mixing water may be responsible for the reported differences in behavior. If this is true, it is probable that more uniform results can be obtained by more vigorous washing, by treatment with a still unspecified salt solution, or by a combination of these processes, that is, washing with the solution.

The study is not complete. The most pertinent data must be confirmed by repeated experiments using different bags of sand until a process that is certain to yield reliable air-entraining test results is developed and confirmed. Tests must then be made with mortars to determine whether or not the dissolved salts have any effect upon air entraining. It would seem that a maximum concentration of 500 ppm in a wash water which is largely drained away would have little influence. However, until this is proved there will always be some question.

No effort is being made to determine the effect of heat treating the sand, since this phase of the problem is being studied by Ottawa Silica Co.

M. R. DeFore (*author*).—The discussion and data supplied by Mr. Griffith are greatly appreciated and are a valuable contribution to the subject.

We have done additional work on the factors influencing the air-entraining characteristics of Ottawa testing sand. We found that five cycles of washing with hot tap water, stirring, and decanting, followed by drying in an oven at 105 C removed most of the air-entraining properties of the sand.

In other tests 5 g of sand as received from the supplier were placed in 10 ml of distilled water, agitated, and allowed to settle for 1 min. The surface tension of the water was then determined. This was also done for sand that had been washed and dried in accordance with the above procedure. We found that the surface tension of the water from the washed sand was 10 to 15 dynes per cm higher than the water from the unwashed sand and was about the same (72 dynes per cm) as for distilled water.

This indicates that washing the sand removes a material that lowers the surface tension of water that has been agitated with the sand.

We plan additional work in which the surface tension of water resulting from the above procedure will be compared with the amount of air entrained by a number of samples of sand.

In conclusion the author wishes to thank those who participated in the discussion and feels that they have added substantially to an understanding of the problem and to its ultimate solution.

Technical Note

Wanted: A Standard Reference Sheet for Water Vapor Permeance

By F. A. Joy and F. M. Gavan

JUST AS THE thermal conductivity of a material is important in many of its applications, so also is its rate of water vapor transmission (WVT). Vapor resisting packages are required to keep salt dry and tobacco damp. A vapor-barrier sheet or coating is generally needed in insulated buildings to avoid condensation.

ASTM Tentative Methods of Test for Measuring Water Vapor Transmission of Materials in Sheet Form (E 96–53 T) provide methods for testing the WVT of films and ASTM Methods of Test for Water Vapor Transmission of Materials Used in Building Construction (C 355–59 T) apply to thick materials. While these methods are good, there are many pitfalls in their application. A series of round-robin tests showing wide variation of results among the participating laboratories was reported by ASTM C-16 on Thermal Insulating Materials in "Water Vapor Transmission Testing," published in *MR&S*, Feb., 1961, pp. 117–121. Among other problems, errors were indicated in the determination of vapor pressure in the test room or cabinet, for which the measuring procedure is not defined in these methods. Usually, vapor pressure is obtained by dew cup or psychrometer, both requiring considerable skill of the operator or rather elaborate equipment. Failure to check results is not unusual. A convenient and dependable device for measuring vapor pressure is needed.

The permeance of a sheet is defined by:

$$\text{Permeance} = \frac{WVT}{\Delta p} \quad \ldots\ldots (1)$$

where:

WVT = weight of vapor transmitted per unit area in unit time, and

Δp = vapor-pressure difference across the sheet.

This ratio largely eliminates the effect of testing under a condition moderately off-standard, and should always be the basis for comparison of barrier sheets. Permeance may be measured in perms.

The vapor pressure in a test space is likely to be cyclic due to control action and the effective vapor-pressure difference over a period of time is not readily obtained by the usual methods. A simple means to obtain this effective value is to test (concurrently) the WVT of a sheet of known permeance, entering these values in Eq 1 to find Δp. What sheet is available for this purpose? A suitable standard reference should have the following features:

1. No effect of age in service,
2. Suitable permeance, not over 1 perm and no great effect from relative humidity,
3. Prompt response to exposure conditions (low mass and no hysteresis effect), and
4. Available duplicate replacement, if needed.

To find such a sheet, The Pennsylvania State University and The Armstrong Cork Co. in 1957 started a cooperative study of Mylar (polyester) supplied by Du Pont Co. A 1-mil thickness was chosen, and six duplicate specimens were permanently sealed to aluminum rings which could then be attached to cups. These specimens have been retested annually at both laboratories. Two were always tested on "dry cups" (containing a desiccant), two on "wet cups" (containing water), and two over a saturated potassium nitrate solution to obtain 92 per cent RH. The test results in 4 yr reveal no effect of age and only a small difference between the "dry-cup" and "wet-cup" values. The 1-mil sheet has very low mass, and its permeance is in a satisfactory range ($\frac{3}{4}$ perm).

In use, a "wet cup" may be preferred, since its vapor pressure is not changed by water loss. With a 4-in. diameter test area (precisely defined), the "wet cup" in a test space at 80 F and 50 per cent RH will lose 0.052 g of water per day. If it is weighed daily, a precision of 1 per cent in the effective vapor pressure difference (Δp) is achieved with a balance sensitive to 0.2 mg. This is readily attained, and greater precision is obtained over a longer period, or by more weighings, if conditions are constant.

The vapor pressure in the space is $P_2 = P_1 - \Delta p$, where P_1 is the vapor pressure over the water. Thus, the precision of P_2 also depends on the measurement of P_1 which is determined from the effective water temperature. At 80 F, 50 per cent RH, an error of 0.15 F in the water temperature leads to 1 per cent error in P_2. Such precision should be readily obtained by a thermocouple or a thermometer in a suitable well in the water or in a massive metal base having a good thermal contact with the cup bottom.

It may be noted that neither the temperature measurement nor the vapor pressure calculation are actually required if all cups under test are "wet cups" and if all have the same temperature. The permeance of any specimen is then determined simply as:

$$P_x = P_s \frac{WVT_x}{WVT_s} \quad \ldots\ldots (2)$$

The subscripts s and x apply to the standard and the unknown sheets.

Similar relations will be seen if a "dry cup" is used for the standard, which is quite feasible with care in desiccant preparation and limitation of its water sorption in service. Two cups, one wet and one dry, should confirm the effective vapor pressure.

Further study of Mylar as a standard reference is now planned by Subcommittee T-IX of Committee C-16 on Thermal Insulating Materials to observe the long-time stability of its permeance and its utility as a laboratory device. It is expected that the following organizations will participate in this program: Armstrong Cork Co., Benjamin Foster Co., Johns Manville Products Corp., National Bureau of Standards, National Research Council (Canada), Pittsburgh Corning Corp., and The Pennsylvania State University.

Accuracy Problems at Rapid Rates of Mechanical Testing

By R. W. FENN, JR., and A. A. MOORE

Ever-increasing rates of loading in mechanical testing present problems in obtaining accurate results with commercially available testing equipment. Problems of measuring load and strain accurately at high speeds are discussed and methods of evaluating equipment response speed are presented. A standard method of calibration at rapid rates of loading is needed.

THE INABILITY of testing machines to record accurately load and strain under rapid rates of loading has been a problem for some time. In 1937 Wilson and Johnson (1)[1] calibrated some commercial testing machines under dynamic loading at rates up to 50,000 lb per min. They found that substantial errors were introduced in many machines by dynamic loading in addition to the errors found by static calibration.

While faster testing machines and recorders have been developed since 1937, no standard procedure for dynamically calibrating these machines has been established. Data for design of missiles have been obtained by making tests in a matter of seconds. ASTM Recommended Practice E 151[2] recommends strain rates of 0.005 (conventional), 0.5 (rapid), and 5 (very rapid) in. per in. per min while the specimen responds elastically to the applied load. A standard ½-in. diameter test bar of steel, which has a modulus of elasticity of 30,000,000 psi, when tested at a strain rate of 0.5 in. per in. per min would have a loading rate of about 3,000,000 lb per min.

In an effort to evaluate the capabilities of some of the commercial testing machines, the authors used a method proposed by Aber and Howell (2) for calibration of extensometers wherein deviations from Young's modulus are considered as errors. Comparison of the work by Fenn (3) to that of Graft and Levinson (4) showed the modulus of elasticity of magnesium alloys to be essentially the same under static and dynamic loading at room temperature. Any change in the slope of the stress-strain curve with increased rates of loading for a given specimen and position in the grips is attributed to a variation in either the indicated strain or load.

TABLE I.—DRUM SPEED AND STRAIN RATE VERSUS EXTENSOMETER DISPLACEMENT.

Extensometer Displacement,[a] in.	Drum Speed, in. per min	Strain Rate,[b] in. per in. per min
0.0001	10	0.010
0.0002	22	0.022
0.0003	25	0.025
0.0004	26	0.026
0.0005	27	0.027
0.001	28	0.028
0.003	29	0.029
0.005	30	0.030
>0.005	30	0.030

[a] Divide by gage length of extensometer, in this case by 2, to obtain strain.

[b] Using a 2-in. gage length Baldwin microformer extensometer at a magnification of 500× on a Baldwin Model MA1C recorder. Example of calculation:

$$\frac{26 \text{ in. (drum speed)}}{2 \text{ in. (gage length)} \times 500 \text{ magnification}} =$$

0.026 (strain rate)

Procedure and Results

Strain Recording

The characteristics of the strain recording systems were checked by a method suggested by Lathrop.[3] When the balancing mechanism of the linear differential transformer in the recorder was disconnected and the core of the linear differential transformer in the extensometer was displaced, the drum rotated continuously in an effort to correct the imbalance. The speed of the drum varied with the amount of displacement in the core of the linear differential transformer on the extensometer. The maximum response speed was determined for a given extensometer movement using a comparator to control the change in gage length and a stop watch to time the drum rotation.

Once the relationship between change in gage length and maximum drum speed was established, a given drum speed indicated a lag of a known amount in the strain recording system.

The data obtained on one commercial microformer extensometer and load-strain recorder are presented in Table I. From these data it is evident that the maximum drum speed of 30 in. per min resulted in a lag greater than the error permitted with a class B2 extensometer (0.0002 in. per in.). At a lag of 0.0002 in. per in. a strain rate of 0.026 in. per in. per min or a drum speed of 26 in. per min was obtained at a magnification of 500×. Any time the recorder was operating at maximum drum speed, the recorded extensometer displacement was low by at least 0.005 in. The core displacement in the linear differential transformer governs recorder speed. Since various magnification ratios may be used ahead of the transformer on various types of extensometers, the results reported in this paper might

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Recommended Practice for Tension Tests of Metallic Materials at Elevated Temperatures with Rapid Heating and Conventional or Rapid Strain Rates (E 151 – 59 T), 1959 Supplement to Book of ASTM Standards, Part 3, p. 59.

[3] R. P. Lathrop, Weidemann Machine Co., King of Prussia, Pa.

R. W. FENN, JR., is chief of the Testing and Instrumentation Section of the Metallurgical Laboratory, The Dow Metal Products Co., Division of The Dow Chemical Co., Midland, Mich. For several years he has been engaged in research on instrumentation, test methods, and the effect of metallurgical variables on mechanical properties at room, elevated, and cryogenic temperatures and has been the author of several papers on these subjects.

A. A. MOORE is chief standards engineer of The Dow Metal Products Co., Division of The Dow Chemical Co., Midland, Mich. He has spent considerable time evaluating the effect of testing variables on the mechanical properties of materials, primarily magnesium alloys.

TABLE II.—RECORDER STRAIN-RATE CAPABILITIES.

Manufacturer	Model and Serial number	Maximum Drum Speed, in. per min	Maximum Strain Rate Capability, in. per in. per min[b]								
			¼-in. Gage Length			1-in. Gage Length			2-in. Gage Length		
			250×	500×	1000×	250×	500×	1000×	250×	500×	1000×
Baldwin	MA1C 1188	30	0.24	0.12	0.06	0.12	0.06	0.03	0.06	0.03	0.015
	MA1CB 1198	100	0.80	0.40	0.20	0.40	0.20	0.10	0.20	0.10	0.05
	MA1B 601	109	0.87	0.44	0.22	0.44	0.22	0.11	0.22	0.11	0.055
	MA1B(M)[a] 640	171	1.37	0.69	0.34	0.69	0.34	0.17	0.34	0.17	0.086
Riehle	RD-5B R74750	Slow									
		18.8, 37.5, 75	0.15	0.15	0.15	0.075	0.075	0.075	0.0375	0.0375	0.0375
		Fast									
		94, 187, 375	0.75	0.75	0.75	0.375	0.375	0.375	0.187	0.187	0.187

[a] Recorder modified in authors' laboratory by changing gear ratios to increase drum speed.

[b] Maximum strain rate = $\frac{\text{maximum drum speed}}{\text{magnification} \times \text{gage length}}$

not be applicable to other extensometer and recorder systems.

Table II summarizes test results on five strain recorder systems and shows that decreasing either the gage length or the magnification ratio permits a higher rate of straining. It must be emphasized that the speeds given in Table II are maximum speeds, and the accuracy of the extensometers and recorder systems was not determined by the above evaluation of response speed.

Load Recording

Calibration of testing machines under dynamic loading as done by Wilson and Johnson (1) is difficult and expensive and would hardly be suitable for field use. Errors found in recording systems evaluated by Wilson and Johnson are inherent in the system, so there is no reason to believe they are any better under dynamic loading today than they were in 1937. It is also reasonable to assume that the errors would increase with an increase in the rate of loading. Some of the newer electronic load-indicating systems available from several manufacturers have minimized lag and some of the inertia problems formerly present.

In an effort to measure the response speed of loading systems in a simple manner, the authors decided to use a method proposed by Aber and Howell (2) for calibration of extensometers. Such a system should be as suitable for calibration of indicated loads in the elastic range as it is for strain if the modulus remains constant. A quick evaluation of the response speed of a load-measuring system can be made using a material with little difference in the static and dynamic modulus (3, 4). The authors do not consider this method suitable for calibration purposes if an accuracy consonant with ASTM Methods E 4[4] is required.

A specimen is loaded in the normal manner, and the load-strain curve is recorded in the elastic range at increasing rates on successive tests. A time-interval marker is used to determine the rate of testing in terms of either load or strain. The loading rate is increased by using the normal controls on the machine. As the loading rates increase, problems of starting, stopping, and maintaining a relatively constant rate are encountered. Any change in the rate of movement of any component is attended by inertial effects. These effects are also present when a specimen is being tested and must be considered in evaluating machine characteristics. It can be concluded that a machine would not be satisfactory at rates of loading where large errors are evident in Young's modulus.

Figure 1 is a series of load-strain curves obtained with a linear-differential-transformer-type extensometer and recorder system and a testing machine with a lapped-ram, Bourdon-tube load-measuring system. Since the maximum strain rate used in this series of tests was 0.048 in. per in. per min while the strain-measuring system capability is 0.20 in.

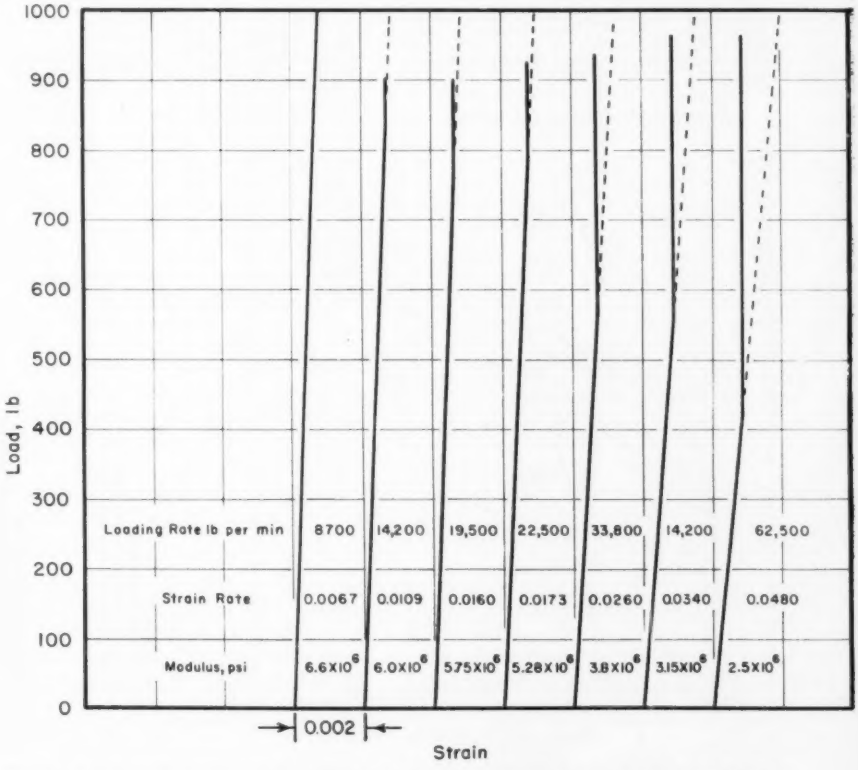


Fig. 1.—Load-strain curves at various rates of loading obtained on a Baldwin 20,000-lb capacity universal testing machine equipped with a lapped-ram, Bourdon-tube load-measuring system, microformer Model MA1CB recorder, and microformer Model T1M 2-in. gage length extensometer.

[4] Methods of Verification of Testing Machines (E 4 – 60 T), 1958 Book of ASTM Standards, Parts 3, 4, 5, 6, 9, and 10.

per in. per min at a strain magnification of 250×, as shown in Table II, it is apparent that the strain-measuring response speed is adequate. The decrease in the modulus of elasticity, therefore, is attributed to the inadequate response speed of the load-measuring system.

When application of the load was stopped, continued recording of load as a vertical straight line demonstrated that there was a time lag in the load recording.

Once a lag in load-recording becomes apparent at certain speeds, or once obvious errors in modulus are noted, the machine is not considered suitable for use at these speeds.

Figure 2 shows the load errors as a function of loading rate obtained from load-strain curves similar to those in Fig. 1. The error is calculated as deviation of the indicated modulus of elasticity from the established value. It is apparent that the loading rate limit on the 1000-lb and 5000-lb scales of this machine are approximately 7000 and 70,000 lb per min, respectively.

The loading-rate capabilities on various scales of four machines studied are shown in Fig. 3(*b*). All values were determined by the method described except those shown with crosshatching. Inability of the operator to stop the machine at the right time during rapid loading prevented evaluation of the ranges represented by the crosshatched values. Since the machine has a single electronic weighing system, the full-scale response speed of this machine is the same on all scales and the loading rate is proportional to the load scale. The loading-rate capabilities shown in crosshatching were calculated on this basis. The response speed of the various scales will not necessarily be proportional to the maximum load of the scale if the machine is equipped with separate sensing devices for each scale.

Figure 3(*a*) is a graph of the loading rate as a function of strain rate in the elastic range for materials with different moduli of elasticity. Rates recommended by ASTM Recommended Practices E 21[5] and E 151[2] are indicated with arrows. A comparison of Figs. 3(*a*) and (*b*) shows that none of the machines studied is suitable for testing a standard ½-in. diameter bar of steel at 0.5 in. per in. per min. A loading rate of 3,000,000 lb per min is required for a ½-in.

[5] Recommended Practice for Short-Time Elevated Temperature Tension Tests of Materials (E 21 – 58 T), 1958 Book of ASTM Standards, Part 3, p. 217.

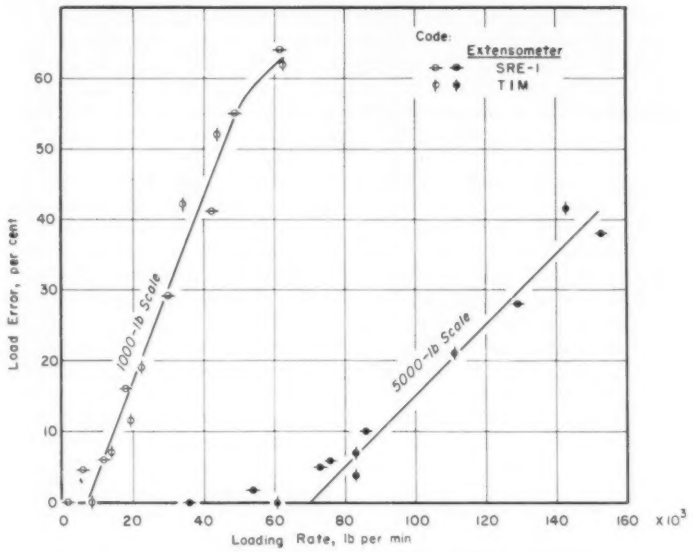
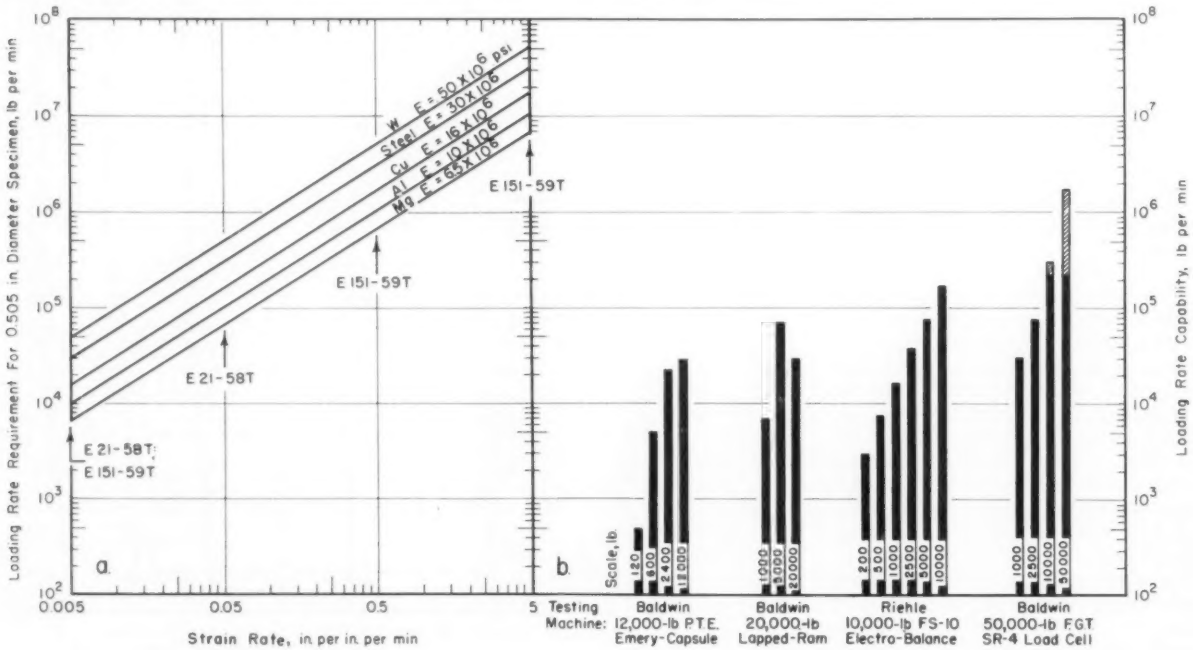


Fig. 2.—Load errors as a function of loading rate for Baldwin 20,000-lb capacity universal testing machine equipped with lapped-ram, Bourdon-tube load-measuring system, and microformer Model MA1CB recorder.


W E = 50 X 10⁶ psi
Steel E = 30X10⁶
Cu E = 16X10⁶
Al E = 10X10⁶
Mg E = 6.5X10⁶
E 151-59T
E 21-58T
E 21-58T; E 151-59T
Loading Rate Requirement For 0.505 in Diameter Specimen, lb per min
Strain Rate, in per in. per min
a
b
Scale, lb
Testing Machine:
Baldwin 12,000-lb P.T.E. Emery-Capsule
Baldwin 20,000-lb Lapped-Ram
Riehle 10,000-lb FS-10 Electro-Balance
Baldwin 50,000-lb FGT SR-4 Load Cell
Loading Rate Capability, lb per min

(*a*) Elastic loading rate requirements per ASTM Recommended Practices E 21 and E 151.

(*b*) Approximate loading rate capabilities of four different types of testing machines in current use.

Fig. 3.—Loading rate requirements compared to testing machine capabilities.

diameter steel specimen tested at this rate. At the strain rate of 5 in. per min given in Recommended Practice E 151, the loading rate on the standard $\frac{1}{2}$-in. diameter test bar of steel would be 30,000,000 lb per min, and on a material with a low elastic modulus such as magnesium, it would be 6,500,000 lb per min. Smaller test bars or larger machines can be used to some extent to circumvent this problem. In general, the use of a large-capacity machine to test a small specimen is not satisfactory, since the load-strain curve covers such a small portion of the available range that readability is poor. The method used to check load-recording characteristics is not considered adequate for calibration but will reveal gross errors. It does use all the machine components and encounters all the problems found in the regular testing procedure.

Conclusions

Gross errors in stress and strain measurement can be determined by the method outlined in this paper. Many of the common testing machines are not suitable for rapid rates of testing. A method of field calibration under rapid rates of loading is needed. A task group of Subcommittee 1 on Calibration of Mechanical Testing Machines and Apparatus of ASTM Committee E-1 on Methods of Testing is seeking suggestions for dynamic calibration techniques. Until the accuracy of testing machines under dynamic loading conditions can be determined, possible errors in test results made at rapid rates of straining will continue to add a factor of uncertainty which must be considered by designers.

References

(1) Bruce Wilson and Carl Johnson, "Calibration of Testing Machines Under Dynamic Loading," *Journal of Research*, National Bureau of Standards, Vol. 19, July, 1937.

(2) W. C. Aber and F. M. Howell, "A Method of Calibrating Extensometers," ASTM BULLETIN, No. 155, Dec., 1948, p. 33.

(3) R. W. Fenn, Jr., "Young's Modulus of Magnesium Alloys as a Function of Temperature and Metallurgical Variables," *Proceedings*, Am. Soc. Testing Mats., Vol. 58, p. 826 (1958).

(4) W. H. Graft and D. W. Levinson, Discussion of "Young's Modulus of Magnesium Alloys as a Function of Temperature and Metallurgical Variables," *Ibid.*, p. 838.

Erratum in Part 1 of 1961 Book of ASTM Standards and Special Compilation of ASTM Specifications for Steel Piping Materials

A SERIOUS ERROR of omission has occurred in the Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 61 T) as it appears in the above-mentioned books. Section 9 of this specification explains the application of the nondestructive electric test. The first sentence of this section should be corrected to read as follows, by the addition of the italicized words: "As an alternate to the hydrostatic test *as applied to Schedule 10 in $\frac{3}{4}$ to 4 in. nominal pipe size*, and when. . . ."

The original intention was that the nondestructive electric test could be specified only for pipe of $\frac{3}{4}$ to 4 in. nominal pipe size in Schedule 10 wall thicknesses.

Spectroscopy Symposium Set for Chicago Next Spring

THE 13TH Annual Mid-America Spectroscopy Symposium, sponsored by the Chicago Section of the Society for Applied Spectroscopy in cooperation with four other Midwest sections, is scheduled for April 30–May 3, 1962, at the Conrad Hilton Hotel in Chicago.

Original papers will explore recent advances in infrared, Raman, optical emission, X-ray, general absorption, nuclear magnetic resonance, electron paramagnetic resonance, and atomic absorption. New items on the program include sessions on vacuum ultraviolet, gas chromatographic preparation of samples for spectroscopic analysis, and an NMR workshop.

Further information is available from John R. Ferraro, Argonne National Laboratory, 9700 South Cass Ave., Argonne, Ill.

International Rubber Conference Set for May, 1962

THE INSTITUT Francais du Caoutchouc is organizing, under the aegis of the International Rubber Research and Development Board, an International Rubber Conference to be held in Paris, May 14–18, 1962.

The conference will explore such questions as: the place of rubber in the world economy, present knowledge of the physics and chemistry of natural rubber, production of natural crude rubber, and comparison of natural and synthetic rubbers.

The detailed program should be available very shortly. For further information, write to the Secretariat of the conference, care of Mr. G. Daugy, 42 Rue Scheffer, Paris 16.

Eastern Analytical Symposium in New York Next Month

THE 1961 EASTERN Analytical Symposium will be held at the Statler-Hilton Hotel in New York, Nov. 15–17. The meeting is sponsored by the Analytical Groups of two sections of the American Chemical Society, four sections of the Society for Applied Spectroscopy, and the Metropolitan Microchemical Society.

Topics on the program include: detectors for gas chromatography, X-ray spectroscopy, storage and retrieval of infrared spectral data, gas chromatography with high molecular weight organic compounds, nuclear magnetic resonance, emission spectroscopy, mass spectroscopy, electroanalytical methods, automation in microchemical analysis, new developments in instrumental techniques for molecular weight determinations, applications of radioisotopes, advances in physical and chemical separations, and applications of nuclear activation analysis

ASTM Committees E-2 on Emission Spectroscopy and E-13 on Absorption Spectroscopy will hold meetings in conjunction with the symposium.

Errata

Following are two omissions in the 1960 *Proceedings:*

On p. 1006, in the paper by M. F. Kaplan, "The Reproducibility of Flexure and Compression Tests for Determining the Strength of Cement," in the fifth line under the heading "Experimental Details" reference (**4**) should be changed to (**3a**), and a new reference (**3a**) should be inserted on p. 1017 to read: "An Investigation into the Methods of Testing the Strength of Cement with Particular Reference to a Suggested Transverse Test and a Modified Cube Compression Test," University of Cape Town (1952).

On p. 1206 the following paper should be included as part of ASTM BULLETIN No. 244, February, 1960: A. G. Roberts, "Improved NBS Abrasive Jet Method for Measuring Abrasion Resistance of Coatings," p. 48 (TP 52).

Pan American Standards Committee*

El Comite Panamericano de Normas Tecnicas (CPNT)

By T. A. MARSHALL, Jr.[1]

The Western Hemisphere today faces a threat to its unity greater than any since the Monroe Doctrine was written 138 years ago. And we should recognize that that document is powerless in the face of this new danger —the battle today is economic and social, not military. The opening guns of the United States counteroffensive were fired last August at the Inter-American Economic and Social Conference, in Punta del Este, Uruguay. There the groundwork was laid for the Alliance for Progress, what President Kennedy has called "a historic turning point in the life of the Western Hemisphere."

At that conference, the United States pledged its treasure and its energies to a great, long-range, cooperative effort to lift the economic and social well-being of an entire continent. With this action, we gave notice to the world that we recognize that continent to be one of the strategic battlefields of the Cold War.

But, in the words of the Foreign Policy Research Institute of the University of Pennsylvania, "government-to-government aid represents only a fraction of the total panorama of possibilities, and a minor fraction at that." What is needed, says the Institute, is to create "an economic climate in which investment and trade can be accelerated."

International trade, however, is a great dialogue for which nations must find a common language. That common language is industrial standards. In a recent pamphlet, the American Standards Association stated it clearly: "Differences in national standards can be a more effective trade barrier than import quotas, currency restrictions, or high tariffs."

If the industrialization of Latin America is a major battle in the Cold War, then industrial standards are strategic weapons in our arsenal.

This was recognized by the Pan American Union, the General Secretariat of the Organization of American States, in a contract entered into with the Pan American Standards Committee (CPNT) on June 29, 1961. That contract will provide $10,000 during this fiscal year for support of the work of CPNT. It charges the CPNT "with the realization of the necessary regional standardization work having great importance for inter-American trade as well as for the facilitating and the fostering of the industrial development of each American State."

The CPNT Program

It was my privilege to attend a meeting of CPNT in Montevideo, Uruguay, in April, 1961, for the purposes of reorganizing and enlarging CPNT, establishing a program of work, and agreeing on a budget to enable it to carry out the program.

Much of the detail of this meeting was reported in the July, 1961, issues of ASA's *The Magazine of Standards* and ASTM's *Materials Research & Standards*. Suffice it to say here that the following were accomplished in Montevideo:

1. The statutes were revised to provide a workable organization and plan for accomplishing the work of CPNT.
2. The membership was enlarged from 6 to 9 countries and now includes the national standards bodies of Argentina, Brazil, Chile, Colombia, Mexico, Peru, the United States of America, Uruguay, and Venezuela. The USA membership is held by ASA.
3. Dr. Alberto Sinay Neves of General Electric, S.A., was elected president. Dr. Neves is a past-president of the Brazilian National Standards Committee (ABNT).
4. Dr. Paulo Sa, director of ABNT, and first president of CPNT, was named permanent honorary president.
5. Senora Ing. Beatriz Ghirelli di Ciaburri, executive director of the Argentine National Standards Organization (IRAM) was named provisional executive secretary.
6. Rio de Janeiro was designated as the temporary headquarters of CPNT.
7. A budget of $9400 was agreed upon for the first year of operation. The funds were to be raised by proportional dues based upon the economic resources of the respective member countries. The USA dues amount to $5000. It should be noted here that this is a minimum operating budget and does not provide for certain capital expense nor for full staffing of the operation.
8. Last, but not least, a program of work for accomplishment during the next three years to fill the initial needs of Latin America was agreed upon.

Now let me expand a little on the last item. In delineating a work program, first attention was given to fundamental standards. These would include preferred numbers, unit conversions, reference temperatures, mathematical symbols, etc.

Next, a list of five groups of materials of prime importance generally to the countries of Latin America was agreed upon. This primary or "A" list covered:

1. Iron and steel products. These standards would include testing specifications, terminology, classification, and marking; specifications for rolled steel products, and specifications for flat products, bars, pipe, structural steel, and ingots.
2. Construction materials (portland cement, wood, glass, compressed building board, asbestos, and asbestos fiber products).
3. Electrical materials. This group would include characteristic specifications and test methods for copper and for motors, generators, meters, transformers, and lamps.
4. Transportation materials (railway, automobiles, etc.).
5. Textile fibers. Classifications and tests.

Finally, a list of five groups of materials of secondary interest was prepared. The items on this "B" list are of major importance to a limited number of the member countries rather than universally as in the primary or "A" list. These secondary or "B" items are:

6. Sugar and alcohol.
7. Vegetable and animal fats and oils.
8. Leather and tanning materials.
9. Canned products.
10. Solid and liquid fuels.

Without going into detail, the committee was interested in developing specifications and test methods for these

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* Presented at the Twelfth National Conference on Standards, sponsored by the American Standards Assn., Oct. 10–12, 1961, in Houston, Tex.

[1] Executive Secretary, American Society for Testing and Materials.

"B" items to suit the needs of the interested countries.

Work on technical standards is to be started promptly by committees composed of engineers and other technologists from the various countries, competent in the fields for which standards are sought. It is expected that many of the standards of various countries will be adapted by modifying them to meet the needs of Latin America as expressed through CPNT. Among the standards already widely used in Latin America are those of a number of the North American standardizing bodies such as ASTM, SAE, and others whose standards are approved by ASA, as well as some ISO recommendations.

What We Can Do to Help

We in the United States must help in this effort to develop Pan American Standards. How successfully we improve relations with our neighbors to the south and assist them in their economic development and industrial growth will depend to a major extent on how well we in America do our share. Success will require the active participation and cooperation of all segments of our economy—industry; government; and the technical, scientific, and educational societies. There are three ways in which we can help:

1. We must actively support and participate in the standards activities of our major American standardizing bodies which cooperate with the Pan American Standards Committee. This will be accomplished largely through support by industry of the activities of ASA and ASTM in these areas.

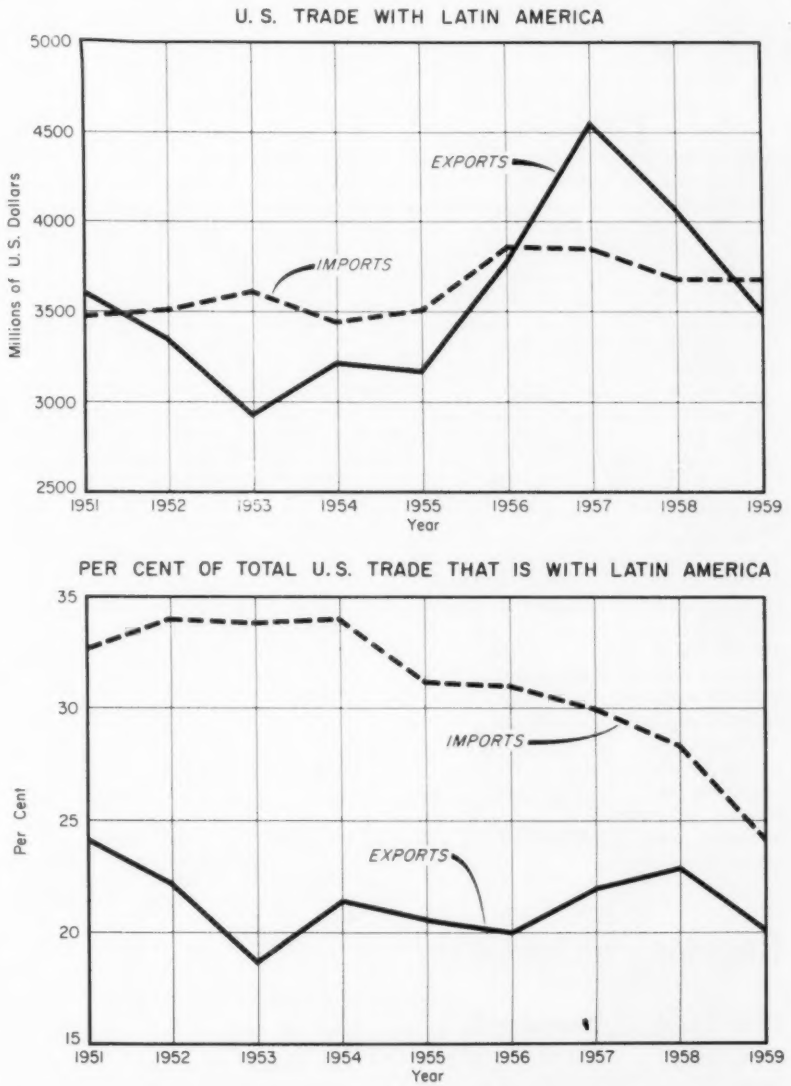
2. We must actively participate in and support the standardizing bodies in Latin American countries through representatives of American industry in those countries.

3. We must develop acceptable translations into Spanish and Portuguese of selected American and ASTM Standards as a base for agreement on Pan American Standards.

In addition to these three ways for specific help by us in the United States, there is one other important factor. We must encourage establishment in the various countries of the Americas of laboratories for determining compliance with the standards. Such laboratories should be staffed by competent engineers, scientists, and technicians of unquestioned integrity. These laboratories should have the equipment and facilities called for by standard test methods for the materials and products covered by the standards. Service by the laboratories should be prompt and reasonably priced to insure regular and continued testing; for, if testing is not done regularly, then experience has shown that the materials and products supplied as standard will not comply with the requirements and the standard will be discredited unjustly.

A delegation from ASTM consisting of Past-President F. L. LaQue and Past-President (then President) A. Allan Bates and I met several months ago with representatives of the Department of Commerce, including Dr. Astin and Dr. McPherson of the National Bureau of Standards; Mr. John C. Green; Mr. E. P. Foley, deputy assistant secretary of the Department of Commerce; and Mr. George Sadler from the International Cooperation Administration, to discuss a proposal to translate ASTM standards for use in Latin America. The Department of Commerce and ICA are currently studying the proposal, which will entail selected ASTM and American Standards, particularly in the work categories designated by the Pan American Standards Committee. We in ASTM are prepared to cooperate fully in this venture. We hope it will gain the active support of industry and government as well.

Perhaps I can best re-emphasize the importance of the Pan American Standards movement in the words of Mr. LaQue in his 1960 presidential address to ASTM: "Our Government is committed to a policy of providing technical assistance to other countries and particularly to what are called underdeveloped countries." Let us not forget that this cannot be done by Government alone, but must be done by each and every one of us.



WESTERN-HEMISPHERE TRADE HAS NOT FLOURISHED

(Top) dollar volume of U.S. trade with Latin America is about where it was ten years ago. (Bottom) proportion of total U.S. trade that is with Latin America has been declining. (Data from "Yearbook of International Trade Statistics 1959," United Nations Department of Economic and Social Affairs, New York, 1960.)

Society Affairs

Publications Preview

Here is a peek through the knothole at what will be pouring off the ASTM presses in the coming year.

THE MANY thousands of pages to be published by the Society in the next twelve months have but one purpose—more effective use of materials by the nation's industry and government. Nearly 3000 standards will appear in the monumental 1961 Book of ASTM Standards, the most authoritative collection of standards for materials in the world. Prepared by the nation's leaders in materials technology—the men who actually produce and use the materials—these standards are the lifeblood of materials commerce in the United States.

The latest findings from materials laboratories will be reported in the *Proceedings* and in some 18 special technical publications. Here is laid the foundation of research on which the up-to-date ASTM standards are based. Here, also, will be found a wealth of information to help the designer and the materials specialist to find their way through the ever more complex world of engineering materials.

These publications are the expression of the Society's purpose—research and standards for materials. During the coming 12 months, as they become available, they will, of course, be announced in *MR&S*.

Regular Publications

1961 Book of Standards

The Book of ASTM Standards is a triennial publication, with supplements issued in the intervening years. It contains all standard and tentative specifications, methods of test, and definitions adopted by the Society. The 1961 edition comprises some 16,700 pages in eleven parts (up 16 per cent over the 1958 edition, which was in ten parts). Not included in these eleven parts are 61 methods for chemical analysis of metals which appear in a separate publication issued in 1960.

The titles of the eleven parts are:

Part 1—Ferrous Metals Specifications
Part 2—Non-ferrous Metals Specifications, Electron Tube Materials, Semiconductors
Part 3—Methods of Testing Metals (Except Chemical Analysis)
Part 4—Cement, Lime, Gypsum, Mortar, Concrete, Mineral Aggregates, Bituminous Materials, Soils
Part 5—Asbestos-Cement Products, Masonry Units, Pipe and Drain Tile, Refractories, Ceramic Whitewares, Porcelain Enamel, Glass, Building Stone, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests
Part 6—Paper, Packaging, Flexible Barrier Materials, Adhesives, Wood, Cellulose, Casein, Leather
Part 7—Petroleum Products and Lubricants
Part 8—Paint, Naval Stores, Coal and Coke, Gaseous Fuels, Industrial Aromatic Hydrocarbons, Engine Antifreezes, Industrial Chemicals
Part 9—Plastics, Carbon Black
Part 10—Textiles, Soap, Sorptive Mineral Materials, Halogenated Organic Solvents, Industrial Water, Atmospheric Analysis, Wax Polishes
Part 11—Rubber, Electrical Insulation

1961 Index to ASTM Standards

This Index is a ready reference for locating any ASTM standard appearing in any of the eleven parts of the Book of Standards and the Methods of Chemical Analysis of Metals. The Index is also of service in ascertaining whether the Society has issued a standard on a specific subject. Standards are listed by subject and also by numerical designation.

Compilations of Standards

Many ASTM standards, in addition to appearing in the eleven-part book, will be published in special compilations grouped conveniently by subject. Many users of the standards prefer the advantages of having all standards in a specific area available in a relatively small volume.

So many factors affect the release of the compilations that it is not possible at this time to give an accurate estimate of their size or the dates they will be available. The size is affected by committee recommendations which may be submitted through the Administrative Committee on Standards, and the date of issue is governed by editorial considerations and the relation of the special compilations to the appearance of the various parts of the Book of Standards. The tabulation given on the next page is, therefore, approximate.

1961 *Proceedings*

This 1300-page volume will record the technical accomplishments of the year, including reports, papers, and discussions offered to the Society during the year and accepted for the *Proceedings*. Although the Society's publications program has expanded greatly in recent years with an ever-increasing number of Special Technical Publications, the *Proceedings* remains the repository of factual information and a record of the Society's work. An important adjunct is a Subject and Author Index to all papers published in any form by the Society in 1961.

Five-Year Index to ASTM Technical Papers and Reports—1956–1960

This five-year index provides a detailed author and subject index to the technical papers and reports dealing with the properties and testing of materials, appearing in ASTM publications covering the period from 1956 through 1960. It supplements the 50-year index covering the years 1898 through 1950 and the five-year index covering the years 1951 through 1955. This index is intended to make information readily available to the materials technologist, the researcher, the librarian, and all others concerned with the fields covered.

Special Publications

Symposium on Erosion and Cavitation (STP 307)—Sponsored by the Administrative Committee on Simulated Service Testing.

The problem of erosion and cavitation is widespread. It has manifested itself in the operation of hydraulic turbines and diesel engines, in the flight of high-speed aircraft through rain; and in the space age it has shown up in the erosion caused by liquid drops in rocket fuels and in the erosion of space vehicles that, it is felt, will occur as a result of collisions with meteorites and micrometeorites. The six papers in this symposium volume will describe the theories of the cavitation-erosion mechanism, review methods and equipment for accelerated tests for measuring resistance to cavitation, and present the results of years of service experience in the use of various materials to resist cavitation erosion.

Symposium on Microviscometry and Papers on Road and Paving Materials (STP 309)—Sponsored by Committee D-4 on Road and Paving Materials.

The sliding plate microviscometer, a recent development, has been used in a series of cooperative tests conducted by Committee D-4 to determine the repeatability and reproducibility of measurements of asphalt viscosity. This five-paper symposium volume will present results of these cooperative tests and illustrate the use of this equipment for measuring the viscosity of asphalt cements at in-service temperatures and for studying the physical behavior of asphalts.

Also to be included in this volume are four general papers on road and paving materials covering a laboratory-field study of hot asphaltic concrete wearing

STANDARDS COMPILATION SCHEDULE

Sponsoring Committee	Title	Approximate Pages	Approximate Appearance Date
A-1	Steel Piping Materials	550	November
A-3	Iron Castings	182	December
A-6	Magnetic Properties	165	November
B-1	Metallic Electrical Conductors	580	February
B-7	Light Metals and Alloys	390	January
B-8	Electrodeposited Metallic Coatings	142	October
B-9	Metal Powders and Metal Powder Products	110	February
C-16	Thermal Insulating Materials	236	February
D-1	Paint, Varnish, Lacquer and Related Products	1316	January
D-2	Petroleum Products and Lubricants (Vol. I)	1200	November
	(Vol. II)	780	February
D-3	Gaseous Fuels	220	February
D-6, D-10	Paper and Paper Products and Shipping Containers	450	November
D-9	Electrical Insulating Materials	820	December
D-11	Rubber and Rubber-like Materials	1070	November
D-13	Textile Materials	1000	October
D-14	Adhesives	300	December
D-15	Engine Antifreezes	72	November
D-16	Benzene, Toluene, Xylene, Solvent Naphtha	100	March
D-19	Industrial Water	512	November
D-27	Electrical Insulating Liquids and Gases	350	January
F-1	Electron Tube Materials	325	January

MOLD COUNT

Twelfth ASTM Photographic Exhibit. D. R. Condon, United States Testing Co., Inc., Hoboken, N. J.

course mixtures, significance of variation of bitumen content of paving mixtures, immediate core volume by presaturation, air permeability of asphalt concrete, and measurement of asphalt viscosity with a vacuum capillary viscometer.

Symposium on Soil Dynamics (STP 305)—Sponsored by Committee D-18 on Soils for Engineering Purposes.

The eight papers in this symposium volume will discuss many of the current concepts in the areas of stress-deformation-time relationships and test instrumentation and measurement. The impetus to study soil dynamics is due mainly to the increased speed and loads of present-day vehicles affecting highway subsoils and also to the practice of dynamic precompaction of subsoils. Both the practicing engineer and the theoretician have a stake in answering the question: Can we develop a mathematical model or dynamic analogy that will enable us to predict the behavior of soils subjected to vibratory loads?

Symposium on Major Effects of Minor Constituents on the Properties of Materials (STP 304)—Sponsored by the Division of Materials Sciences.

This symposium volume, which is part of a continuing program of the Society's new Division of Materials Sciences, will weave a common thread through all the states of matter—solids, liquids and gases. The objective: to review and find common ground for the metallurgist, the ceramist, the organic chemist, the plasma physicist, and the engineer. The five papers comprising this symposium volume will cover impurity effects in high-purity metals, the effect of impurities on the properties of ceramic materials, the role of minor constituents in organic materials structures, the problem of gas purity in plasma research and technology, and effects of small amounts of extraneous materials on the properties of petroleum, petroleum products, and related liquids.

Symposium on Elevated-Temperature Compression Testing of Sheet Materials (STP 303)—Sponsored by Joint ASTM-ASME Committee on Effect of Temperature on the Properties of Metals.

Compression testing of sheet specimens for determination of yield strength at room temperature is covered by ASTM Method E-9, which describes several jigs developed to support thin sheet material. These jigs become unsuitable at elevated temperatures because of increasing friction between the specimen and jig or relaxation of the jig, leaving the column unsupported. Methods to overcome these problems and data obtained with these methods will be described in the six papers comprising the symposium volume. Since it has been estimated that 60 to 90 per cent of an airframe must be designed for compression, this symposium will be a valuable contribution.

Symposium on Evaluation of Metallic Materials in Design for Low-Temperature Service (STP 302)—Sponsored by Joint ASTM-ASME Committee on Effect of Temperature on the Properties of Metals.

In response to the continually increasing interest in low-temperature processes, transportation of liquefied gases, and the use of these products in the rocket and missile industry, this symposium was organized. Its purpose is to provide engineers and designers concerned with the design of pressure vessels and other structures for low-temperature service with a better understanding of the various criteria and theories for design against brittle failure and their limitations and applications. In the symposium volume will be 14 papers presenting recent concepts in low-energy brittle fracture of metals together with suggested research to developed these concepts, and an interpretation of laboratory data of new test work not only on the commonly used metals but also on many of the newly developed metals and alloys.

Symposium on Radiation Effects in Refractory Fuel Compounds (STP 306)—Sponsored by Committee E-10 on Radioisotopes and Radiation Effects.

The purpose of this symposium volume is to provide a means of dissemination and discussion of the latest data available concerning the effects of radiation on the properties of refractory fuel compounds. Such data are directed, insofar as possible, toward an understanding of the basic mechanisms which produce damage in refractory fuel compounds as a result of the fission process. Since the data are new and cover some of the major problems now being encountered in refractory fuels, particularly UO_2, it is believed that the twelve papers in this symposium volume will be of considerable value.

Symposium on Extension of Sensitivity for Determining Various Constituents in Metals (STP 308)—Sponsored jointly by Committees E-2 on Emission Spectroscopy and E-3 on Chemical Analysis of Metals.

This symposium volume will furnish information concerning what methods are useful for determining extremely small amounts of various elements in metals, what the limits of detection are for these elements, what obstacles must be overcome to obtain increased sensitivity, and what must be done to overcome these obstacles. Analytical methods of greater sensitivity are of importance because of the increased interest in the effects of trace concentrations of elements on the physical and mechanical properties of high-purity metals. The six papers in the symposium volume will discuss separation of desired constituents from matrix and interfering elements prior to certain chemical and spectrographic determinations and will describe recent progress in radioactivation, electrochemical, spectrographic, electron microprobe, and solids mass spectrometric analysis.

Symposium on Testing Building Constructions (STP 312)—Sponsored by Committee E-6 on Methods of Testing Building Constructions.

This symposium volume will cover methods of testing various types of building assemblages. The following fields will be covered by the five papers comprising the symposium: methods for measuring sound transmission loss, measurements of heat transmission and moisture movements in roof constructions, testing lightweight metal curtain walls, testing masonry curtain walls, and full-scale test on a house roof under simulated snow load.

Symposium on Non-Newtonian Viscometry (STP 299)—Sponsored by Committee D-2 on Petroleum Products and Lubricants.

The measurement of viscosity is of obvious importance in assessing the flow properties of mineral oils and constituents. Many oils exhibit non-Newtonian behavior. This symposium volume will attempt to bring together the latest thinking on the problem of describing and measuring non-Newtonian flow properties. Eleven papers cover this important subject.

Materials and Electron Device Processing (STP 300)—Sponsored by Committee F-1 on Materials for Electron Tubes and Semiconductor Devices.

This symposium volume will bring up to date the knowledge about the materials and processing problems in electronic device fabrication which were treated in the 1958 Symposium on Cleaning Electronic Device Components and Materials (*STP 246*). The 31 papers will deal extensively with materials and processing problems common to electronic device fabrication and the chemistry and physics of their operation, as well as similar problems encountered in production of space apparatus. The volume will contain the following chapters: air-borne contaminants, analytical methods and instrumentation, processing apparatus and techniques, materials and processing techniques, gaseous contaminants, and influence of cleaning

on device performance. Since many contamination, processing technique, and material problems are common to other industries, such as pharmaceuticals, optics, and aircraft, many of the topics will be of interest and importance to people from these areas.

Handbook of Vapor Degreasing (STP 310)—Sponsored by Committee D-26 on Halogenated Organic Solvents.

This handbook will serve as a guide to consumers who desire comprehensive information on the vapor degreasing process. To those who are contemplating the purchase of cleaning equipment, this information should aid materially in helping them determine whether the vapor degreasing process is best suited for their cleaning problem. Those who now own and operate vapor degreasing equipment will benefit in turn by following the procedures recommended. The benefits will be a better cleaning job at lower cost and with greater safety. The chapters in this volume will be: definition and process description, applications for vapor degreasing, selection of a vapor degreasing solvent, vapor degreasing equipment, degreaser operation, and general hazards of perchlorethylene and trichlorethylene.

1960 Supplement to the Bibliography and Abstracts on Electrical (Contacts STP 56-0)—Sponsored by Committee B-4 on Metallic Materials for Thermostats and for Electrical Resistance, Heating, and Contacts.

This supplement to the 1952 edition will include new references in this field for the year 1960. Since the 1952 edition, a supplement has been issued each year, showing the continuing interest and need for this volume. The 1952 book with its eight supplements covers developments in the electrical contact field from 1835 to 1960.

Bibliography and Abstracts on Thermostat Metals, 1806–1959 (STP 288)—Sponsored by Committee B-4 on Metallic Materials for Thermostats and for Electrical Resistance, Heating, and Contacts.

This bibliography is being prepared along the same lines as the Bibliography and Abstracts on Electrical Contacts. Some of the subjects to be included are applications; bond testing; books on thermostat metals; cladding; corrosion; design; emissivity; fabrication; high-temperature materials and performance; mechanical, metallographic, and physical characteristics; shapes; standards; and thermal conductivity.

Index to the Literature on Spectrochemical Analysis, Part V. 1956–1960 (STP 41-E)—Sponsored by Committee E-2 on Emission Spectroscopy.

This is the fifth of a series of bibliographical surveys of the literature on emission spectrochemical analysis. The first was published in 1941 and covered the literature for the years 1920 through 1939, the second part was published in 1947, the third in 1954, and the fourth in 1959. The number of references for a given period increases with each edition of this book, and this can be attributed to the extensive applications of spectrochemical analysis and especially to papers in the field of flame photometry. The abstracts are largely quoted from *Chemical Abstracts*, but occasionally they are abridged or quoted from other publications or specially prepared.

1960 References on Fatigue (STP 9-L)—Sponsored by Committee E-9 on Fatigue.

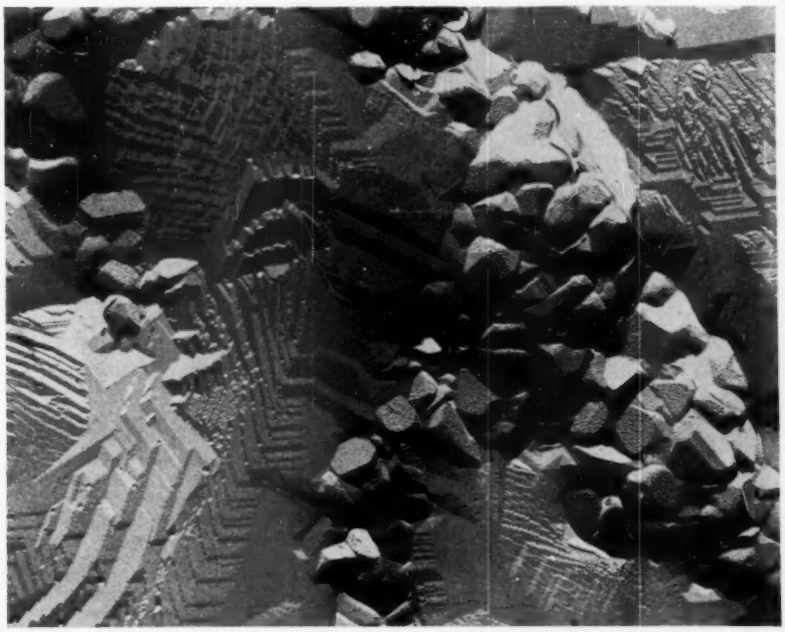
This list of references to articles published in 1960 dealing with fatigue of structures and materials will follow the plan used in previous annual lists from 1950 through 1959. References will be generally so arranged that sheets can be cut apart for filing according to any desired plan. Brief abstracts will be included when these are readily available.

Evaluation of Compression Set Testing—Standard versus Variable Deflection Methods (STP 311)—Sponsored by Committee D-11 on Rubber and Rubber-Like Materials.

The standard method for measuring the compression set of vulcanized elastomers is identified by ASTM Designation D 395. This standard covers two test procedures using different types of load applications. The International Standards Organization is presently considering the adoption of a standard deflection of 25 per cent on all compression set tests on elastomeric compounds regardless of hardness. Subcommittee X on Physical Properties of Committee D-11 initiated a program to compare these two testing techniques. The purpose of this paper is to report the results of this investigation and to acquaint interested personnel with the scope as well as the implications of this work.

Supplement to Manuals of Engine Test Methods for Rating Fuels—Sponsored by Committee D-2 on Petroleum Products and Lubricants.

This supplement will contain information that will bring up to date the 1960 Manual for Rating Motor Fuels by Motor and Research Methods, the 1958 Manual for Rating Aviation Fuels by Supercharge and Aviation Methods, and the 1959 Manual for Rating Diesel Fuels by the Cetane Method. It will include all changes and additions to these three manuals that have been approved by Committee D-2 and the Society up to July 1, 1961.



STRIATION FORMATION ON SURFACE OF IRON, 12 ALUMINUM SPECIMEN HELD AT 1175 C FOR 6 HR UNDER 100-MM OXYGEN

Between islands of crystallized aluminum oxide, surface diffusion leads to a low-energy system of striations along certain crystallographic planes. The very thin oxide film covering these striations becomes unstable, and atoms situated at projecting edges migrate to lower regions and form globules. Carbon replica made from chromium shadow cast cellulose acetate primary replica. Magnification 20,000X, reduced for publication. Twelfth ASTM Photographic Exhibit. Honorable mention, electron micrographs, replicas. E. F. Koch and W. C. Hagel, General Electric Co., Schenectady, N. Y.

ACTIONS ON STANDARDS

The Administrative Committee on Standards is empowered to pass on proposed new tentatives and revisions of existing tentatives, tentative revisions of standards, and the withdrawal of tentatives and standards offered between Annual Meetings of the Society. On the dates indicated, the Standards Committee took the following actions. Anyone interested in securing copies of the standards should write to Headquarters regarding their availability.

Steel (Accepted August 3, 1961)

Tentative Specification for Quenched-and-Tempered Steel Bolts and Studs with Suitable Nuts and Plain Hardened Washers (A 325 – 58 T)

Revision.—Bolts for several uses have been ordered under Specification A 325 – 58 T, and Committee A-1 felt that each end use should be covered by a separate specification. The revised specification will cover high-strength steel bolts for structural steel joints. It has been coordinated with the Specifications for Structural Bolts Using ASTM A325 Bolts issued by the Research Council on Rivet and Bolted Structural Joints of the Engineering Foundation. Another specification covering the other end-use of the bolts formerly covered by A 325 – 58 T is in its final stage of preparation.

Iron-Chromium, Iron-Chromium-Nickel and Related Alloys (Accepted August 3, 1961)

Revision and Reversion to Tentative of Standard Specification for:

Corrosion-Resisting Chromium Nickel Steel Plate, Sheet, and Strip (A 167 – 58)

Corrosion-Resisting Chromium Steel Plate, Sheet, and Strip (A 176 – 54)

Tentative Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels (A 240 – 58 T)

Revision.—Additional grades of steel have been added, and revisions have been made in the chemical requirements of some of the existing grades.

Titanium (Accepted August 9, 1961)

Tentative Specification for Titanium and Titanium Alloy Forgings (B 381 – 61 T)

New Tentative.—This specification has been prepared in view of the increasing quantitites of forgings made of titanium and titanium alloy. It covers four grades of unalloyed titanium and five grades of titanium alloy.

Tentative Specification for Titanium and Titanium Alloy Bare Welding Rods and Electrodes (B 382 – 61 T)

New Tentative.—This specification prescribes requirements for titanium and titanium alloy welding rods for use with the gas tungsten-arc welding process and electrodes for use with the gas metal-arc welding process.

Tentative Specification for Seamless and Welded Unalloyed Titanium Tubing (B 338 – 58 T)

Revision.—Changes have been made in Section 8 and Table IV relating to the flaring requirements.

Corrosion of Non-Ferrous Metals and Alloys (Accepted August 9, 1961)

Tentative Method of Corrosion Testing of Decorative Chromium Plating by the Corrodkote Procedure (B 380 – 61 T)

New Tentative.—The Corrodkote test is conducted by application of a slurry containing corrosive salts to test specimens, allowing the slurry to dry, and exposing the test specimens coated with the slurry to a high relative humidity for a specified period of time. The Corrodkote test is primarily applicable to copper-nickel-chromium or nickel-chromium plated parts.

On September 12, 1961, the Standards Committee took the following actions:

Wrought Iron

Tentative Specification for Welded Wrought-Iron Pipe (A 72 – 59 T)

Revision.—The hydrostatic test pressures have been raised for wrought iron buttwelded pipe of all grades in order to improve the quality of welds of the pipe.

Resistance Materials

Standard Method of Test for Temperature-Resistance Constants of Alloy Wires for Precision Resistors (B 84 – 52)

Revision and Reversion to Tentative.—This test has been revised to cover nickel-chromium-aluminum alloys having low temperature coefficient of resistance in addition to manganin and constantan.

Clay Pipe

Tentative Specification for Vitrified Clay Liner Plates (C 479 – 61 T)

New Tentative.—The vitrified clay liner plates covered by this specification are those used to line or face pipe, culverts, abutments, structures, or appurtenances composed of materials that are subject to corrosion or erosion due to acid, alkali, or scouring waste water and other liquids.

Tentative Specification for Standard-Strength Perforated Clay Pipe (C 211 – 57 T)

Revision.—Extra-strength pipe requirements have been added to the specification so that it now covers both standard- and extra-strength pipe.

Manufactured Masonry Units

Tentative Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units (C 126 – 60 T)

Revision.—Provision has been made for further minimum requirements for multicored units with respect to thickness of connecting webs. Also, because of the danger involved in the careless or improper care and operation of autoclave equipment, precautionary instructions were added for this equipment.

Tentative Specification for Vitrified Clay Filter Block for Trickling Filters (C 159 – 59 T)

Revision.—Minor changes have been made in paragraphs (*a*) and (*c*) of Section 11 on Workmanship and Finish.

Tentative Method of Test for Drying Shrinkage of Concrete Block (C 426 – 58 T)

Revision.—The revision provides for further control of the drying oven procedure by specifying type of calcium chloride, when used; additional detail to aid in the drying procedure; and a more clear-cut and definitive description of paragraph (*a*) of Section 5 on Setting Gage Plugs.

Bituminous Materials for Roofing

Tentative Method of Test for Sieve Analysis of Nongranular Mineral Surfacing for Asphalt Roofing and Shingles (D 452 – 60 T)

Revision.—Refinements and improvements have been made in the test.

Standard Method of Test for Sieve Analysis of Granular Mineral Surfacing for Asphalt Roofing and Shingles (D 451 – 40)

Revision and Reversion to Tentative.—General refinements and improvements have been made in the test.

Electrical Insulating Materials

Tentative Specifications for Kraft Dielectric Tissue, Capacitor Grade (D 1930 – 61 T)

New Tentative.—There is now available for use by industry a specification for the special types of paper used as dielectrics in capacitors. Four types of tissue are covered.

Tentative Specifications for Fully Cured Silicone-Rubber-Coated Glass Fabric and Tapes for Electrical Insulation (D 1931 – 61 T)

New Tentative.—The fully cured, silicone-rubber-coated glass fabric covered by this specification is a relatively new type of heat-resistant electrical insulation. It is available in sheet form, full-width rolls, and tapes.

Tentative Method of Test for the Evaluation of Thermal Endurance of Flexible Electrical Insulating Varnishes (D 1932 – 61 T)

New Tentative.—This method provides industry with a test for predicting the relative thermal endurance of flexible electrical insulating varnishes when applied to a glass fabric. It is not intended for varnishes that lose high percentages of their strength electrically when flexed before aging. It provides a means of selecting the varnish most likely to give the longest useful life in service at elevated temperatures.

Tentative Methods of Testing Vitrified Ceramic Materials for Electrical Applications (D 116 – 60 T)

Revision.—The thermal shock test has been modernized, and provision has been made for greater temperature differentials than those of the present methods.

Tentative Methods of Sampling and Testing Untreated Paper Used for Electrical Insulation (D 202 – 60 T)

Revision.—The test methods for acidity-alkalinity-pH have been brought up-to-date. The methods consist of hot-water extraction of untreated electrical papers followed by a pH measurement or an acidity-alkalinity titration of the extract solution.

Tentative Methods of Testing Flexible Treated Sleeving Used for Electrical Insulation (D 350 – 57 T)

Revision.—These methods have been extended to cover the newer materials in wide use throughout the electrical industry.

Tentative Specifications for Flexible Treated Sleeving Used for Electrical Insulation (D 372 – 53 T)

Revision.—The purpose of the revision is to bring the classifications of these materials up-to-date and more in line with the many types of electrical insulating sleevings now in use.

Plastics

Tentative Methods of Test for Particle Size (Sieve Analysis) of Plastic Materials (D 1921 – 61 T)

New Tentative.—Procedures are now provided for measuring the particle size of plastic materials in the powdered, granular, or pelleted forms in which they commonly are supplied. As only dry sieving procedures are described, the lower limit of measurement is considered to be about 37 μ (U.S. Standard Sieve No. 400). For smaller particle sizes, sedimentation methods are recommended.

Tentative Method of Test for Propagation Tear Resistance of Plastic Film and Thin Sheeting (D 1922 – 61 T)

New Tentative.—The use of plastic film and thin sheeting for packaging as well as many other uses has created the need for methods for measuring tear resistance. This test is modeled after a method for the tear resistance of paper.

Tentative Method of Test for Tensile Properties of Thin Plastic Sheet by Means of Inclined-Plane Test (D 1923 – 61 T)

New Tentative.—This method of test describes a procedure for determining tensile properties of plastics in the form of thin sheeting less than 1.0 mm (0.04 in.) thick. The method uses an inclined-plane weighing head to measure the load applied to break the specimen. The method was previously Method C of the Test for Tensile Properties of Thin Plastic Sheets and Films (D 882) and was separated because of the basic incompatibility of the methods with respect to test procedure and methods of loading test specimens.

Tentative Recommended Practice for Determining Resistance of Plastics to Fungi (D 1924 – 61 T)

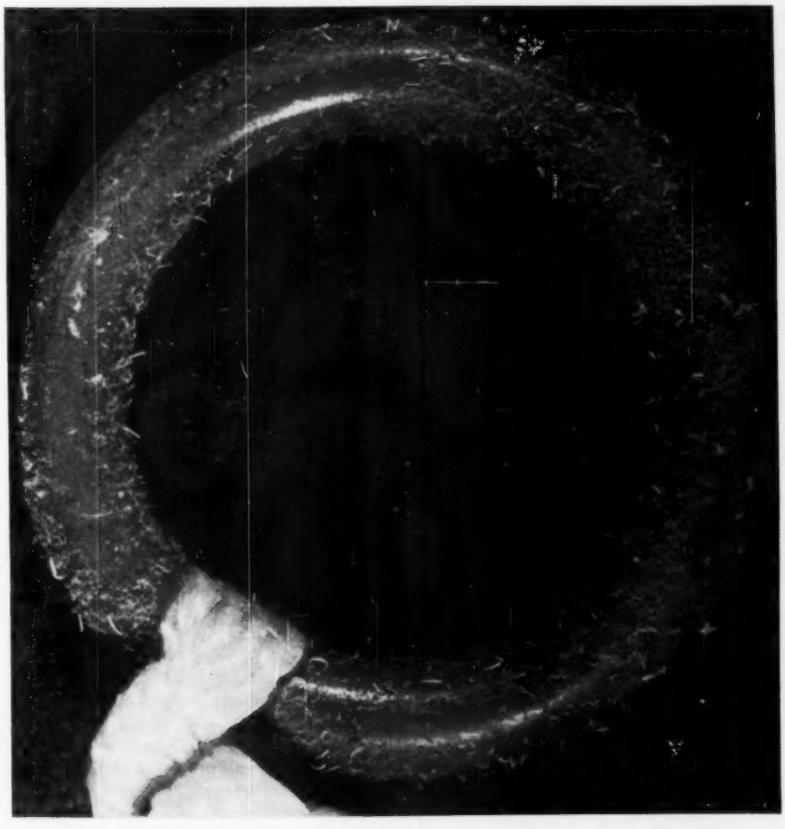
New Tentative.—A procedure is now provided for determining the effect of fungi on the properties of plastics in the form of molded and fabricated articles, tubes, rods, sheets, and film materials. Changes in optical, mechanical, and electrical properties may be determined by the applicable ASTM methods.

Tentative Method of Test for the Coefficient of Friction of Plastic Film (D 1894 – 61 T)

Revision.—The revision allows more rapid testing with less elaborate equipment.

Tentative Method of Test for Tensile Properties of Plastics (D 638 – 60 T)

Revision.—Section 3 on Significance was



FUNGUS GROWTH ON RUBBER COMPONENT OF RADAR FUSE TEST SET

Twelfth ASTM Photographic Exhibit. Honorable mention, general class, color prints—materials. J. Normand, Pitman-Dunn Laboratories, Frankford Arsenal, Philadelphia, Pa.

revised to broaden the understanding of data obtained from the tensile testing of plastics. In addition, Type IV specimen was added to the dimensional standards table for specimens $\frac{1}{4}$ in. or under in Fig. 1.

Tentative Methods of Test for Tensile Properties of Thin Plastic Sheeting (D 882 – 56 T)

Revision.—The methods have undergone comprehensive upgrading and updating based on current usage and technology.

Tentative Definitions of Terms Relating to Plastics (D 883 – 61 T)

Revision.—Definitions have been added for nonrigid plastic, semirigid plastic, and rigid plastic.

Tentative Abbreviations of Terms Relating to Plastics (D 1600 – 60 T)

Revision.—The abbreviation UP has been added for urethane plastics.

Tentative Nomenclature of Descriptive Terms Pertaining to Plastics (D 675 – 60 T), and
Tentative Definition of Terms Relating to Plastics (D 883 – 61 T)

Consolidation.—These two documents have been combined to form the Tentative Nomenclature of Terms Relating to Plastics (D 883 – 61 T).

Atmospheric Sampling and Analysis

Tentative Recommended Practice for Conversion Units and Factors Relating to Atmospheric Analysis (D 1914 – 61 T)

New Tentative.—In the interest of uniform methods of study, analysis, and reporting of air pollution, Committee D-22 is attempting to establish standard units of expression.

Cellulose and Cellulose Derivatives

Tentative Method of Test for Chromatographic Analysis of Chemically Refined Cellulose (D 1915 – 61 T)

New Tentative.—This method covers the rapid and routine testing of large numbers of chemically refined cellulose samples with high accuracy and precision.

Tentative Methods of Test for Carboxyl Content of Cellulose (D 1926 – 61 T)

New Tentative.—These methods cover the determination of the carboxyl content, or ion-exchange capacity, of cellulose from any source. Two methods are described, the sodium chloride–sodium bicarbonate method, and the methylene blue method.

Methods of Testing

Tentative Method for Guided Bend Test for Ductility of Welds (E 190 – 61 T)

New Tentative.—This method covers a guided bend test for the determination of soundness and ductility of welds in ferrous and nonferrous products. Defects not shown by X-rays may appear in the surface of a specimen when it is subjected to progressive localized overstressing. This guided bend test has been developed primarily for plates and is not intended to be substituted for other methods of bend testing. It is a companion method to the Tentative Method of Free Bend Test for Ductility of Welds (E 16 – 57 T).

Tentative Definitions of Terms Relating to Microscopy (E 175 – 61 T)

New Tentative.—These definitions have been prepared by Subcommittee 28 on Microscopy of Committee E-1. They have been coordinated with similar terms in the Definitions of Terms Relating to Metallography (E 7 – 55 T) prepared by Committee E-4 on Metallography.

Tentative Recommended Practice for Conducting Natural Light (Sunlight and Daylight) Exposures Under Glass (E 187 – 61 T), and
Tentative Recommended Practice for Operation of Enclosed Carbon-Arc-Type Apparatus for Artificial-Light Exposure Tests (E 188 – 61 T)

New Tentatives.—Recommended Practice E 187 describes two procedures for evaluating the resistance of all types of materials to the action of natural light under glass. Recommended Practice E 188 describes the basic principles and standard operating conditions required to ensure uniform exposures in artificial-light exposure apparatus which uses the enclosed carbon arc lamp as the source of radiation. Both are companion standards to the Recommended Practice for Operation of Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Artificial Weathering Test (E 42 – 57).

Tentative Methods of Tension Testing of Metallic Materials (E 8 – 57 T)

Revision.—Certain details of the methods have been clarified.

Standard Specifications for Enclosures and Servicing Units for Tests Above and Below Room Temperatures (D 1197 – 56)

Revised and Reverted to Tentative.—These specifications as originally prepared by Committees D-9 and D-20 were applicable only to plastics and electrical insulating materials. The specifications have been transferred to the jurisdiction of Committee E-1 and have been broadened to cover additional materials. The designation has been changed to E 197 – 61 T.

Standard Definitions of Terms Relating to Specific Gravity (E 12 – 57)

Revision and Reversion to Tentative.—These definitions have been brought up-to-date in accordance with current usage. The title has been changed to "Definitions of Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases."

Standard Definitions of Terms Relating to Methods of Mechanical Testing (E 6 – 61)

Tentative Revision.—This tentative revision affects Note 2 under the definition for "strain," and the definitions for "fatigue" and "fatigue strength at N cycles."

Metallography

Tentative Recommended Practice for Determining Temperature-Electrical Resistance Characteristics (EMF) of Metallic Materials (E 189 – 61 T)

New Tentative.—This recommended practice covers the determinations of the temperature versus electrical resistance characteristics of metallic materials. The fundamental measurements are those of temperature and electrical resistance which are usually made for the purpose of finding thermal critical temperatures (phase changes), finding coefficients or changes in electrical resistance, or making simulated service tests.

Standard Methods for Estimating the Average Ferritic Grain Size of Low-Carbon Steels (E 89 – 52),
Tentative Method for Estimating the Average Grain Size of Non-ferrous Metals, Other Than Copper, and Their Alloys (E 91 – 51 T), and
Standard Classification of Austenite Grain Size in Steels (E 19 – 46)

Withdrawn.—These methods and classification have been replaced by the Standard Methods for Estimating the Average Grain Size of Metals (E 112 – 61).

Tentative Recommended Practice for Identification of Crystalline Materials by the Hanawalt X-ray Diffraction Method (E 43 – 49 T)

Withdrawn.—This recommended practice has been withdrawn, since it is considered to be quite obsolete. A replacement document is in preparation by Subcommittee VI on X-ray Methods of Committee E-4.

Methods of Testing Building Constructions

Recommended Practice for Laboratory Measurement of Air-borne-Sound Transmission Loss of Building Floors and Walls (E 90 – 55)

Revision and Reversion to Tentative.—The recommended practice has been generally revised based on the development of new methods of test and new information.

Actions on Standards

Materials for Electron Tubes and Semiconductor Devices

Tentative Method for Evaluation of Glass-to-Metal Headers for Electron Devices (F 18 – 61 T)

New Tentative.—This reference method specifies acceptance requirements for headers used in electron devices. The header may be defined as an external metal member of cylindrical, oval, or other shape into which is sealed one or more wire leads or metal tubulations, through a glass medium. The metal parts may be plated or unplated and the glass may be clear or opaque.

Tentative Method for Tension and Vacuum Testing Metallized Ceramic Seals (F 19 – 61 T)

New Tentative.—This method covers the apparatus, specimen, and procedure for tension and vacuum testing metal-ceramic seals to determine the bond strength of brazed, metallized ceramics. This method is not to be considered as an absolute tension test for the ceramic.

Tentative Method of Test for Sublimation Characteristics of Metallic Materials by Electrical Resistance (F 278 – 55 T)

Revision.—Considerable revision has been made to improve the sensitivity of the test. The cathode temperature is held more precisely by thermocouple measurement instead of by adjusting heater voltage for brightness temperature.

Tentative Method of Test for Interface Impedance Characteristics of Vacuum Tube Cathodes (F 300 – 57 T)

Revision.—The revision incorporates improved test equipment and advanced techniques, effectively increasing the sensitivity of the measurement. The property is important in high-frequency and computer applications of tubes. The title has been changed to, "Methods of Measuring Cathode Interface Impedance Characteristics of Electron Tubes."

Tentative Specifications for Tungsten Wire for Electronic Devices and Lamps (F 288 – 57 T)

Revision.—Significant revisions in scope, general requirements, and other matter were made adding details on finish and listing of standard sizes of wire to bring the specification into line with industry practice.

Standard Methods for Measuring Mica Stampings or Substitutes Used in Electronic Devices and Lamps (F 652 – 51)

Revision and Reversion to Tentative.—Use of the methods prompted changes in the subject matter and editorial format.

Leather

Tentative Method of Test for Resistance to Wetting (Spray Test) of Garment-Type Leather (D 1913 – 61 T)

New Tentative.—Garment-type leather is often used under wet conditions, and this test evaluates the ability of the leather to resist water.

Effect of Temperature on Properties of Metals

Tentative Recommended Practice for Conducting Creep and Creep-Rupture Tension Tests of Metallic Materials Under Conditions of Rapid Heating and Short Times (E 150 – 59 T), and

Tentative Recommended Practice for Tension Tests of Metallic Materials at Elevated Temperatures with Rapid Heating and Conventional or Rapid Strain Rates (E 151 – 59 T)

Revision.—Changes were made in the close tolerances presently specified on the basis that they were unwarranted, time-consuming, and expensive to attain. The requirement for establishing stress-strain loading curves was deleted.

Papers Invited for Electronic Components Conference

THE 1962 Electronic Components Conference, to be held in Washington, D. C., May 8–10, 1962, invites papers on the subjects of electronic components and materials. Among the suggested topics are: combined function devices (integrated thin-film circuits, multiple semiconductor devices, miniature modules); solid-state applications (ferroelectric, ferromagnetic, thermoelectric, magneto-optic, electroluminescent); processing, assembly, and measuring techniques; nondestructive testing; and electronic materials.

Sponsoring societies for the conference are the American Institute of Electrical Engineers, Institute of Radio Engineers, and the Electronic Industries Assn. Participating societies are the American Society for Quality Control and the Society for Nondestructive Testing.

Fifteen copies of a 500-word summary should be submitted to Henry A. Stone, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

ASTM MEETINGS

Date	Group	Place
Nov. 1	Joint Committee on Chemical Analysis by Powder Diffraction Methods	Pittsburgh, Pa. (Mellon Inst.)
Nov. 1–2	Committee D-15 on Engine Antifreezes	Tarrytown, N. Y.
Nov. 2–3	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Skytop, Pa.
Nov. 14–15	Committee E-11 on Quality Control of Materials	ASTM Headquarters
Nov. 14–16	International Symposium on Electrical Contacts	University Park, Pa. (Pa. State Univ.)
Nov. 15–17	Committee E-2 on Emission Spectroscopy	New York, N. Y.
Nov. 16	Committee E-13 on Absorption Spectroscopy	New York, N. Y.
Nov. 16–17	Joint Committee on Leather	Salem, Mass. (Hawthorne Hotel)
Nov. 21	Committee E-1 on Methods of Testing	ASTM Headquarters
Nov. 27–29	Committee C-1 on Cement	Lafayette, Ind. (Purdue Univ.)
Nov. 29–Dec. 1	Committee C-9 on Concrete and Concrete Aggregates	Lafayette, Ind. (Purdue Univ.)
Dec. 4–5	Committee B-6 on Die-Cast Metals and Alloys	Washington, D. C. (Mayflower)
Dec. 6–7	Committee B-7 on Light Metals and Alloys, Cast and Wrought	Washington, D. C. (Willard)
	1962	
Feb. 5–9	**Committee Week**	**Dallas, Tex. (Statler-Hilton)**
June 24–29	**Annual Meeting**	**New York, N. Y. (Statler-Hilton)**
Sept. 30–Oct. 5	**Pacific Area Meeting**	**Los Angeles, Calif. (Statler-Hilton)**
	1963	
Feb. 4–8	**Committee Week**	**Montreal, P. Q. (Queen Elizabeth)**
June 23–28	**Annual Meeting**	**Atlantic City, N. J. (Chalfonte-Haddon Hall)**

TECHNICAL COMMITTEE NOTES

E-18 Seeks Help on Sensory Bibliography

COMMITTEE E-18 on Sensory Evaluation of Materials and Products, through its Subcommittee IV on Instrumental-Sensory Relationships, has undertaken a critical review and bibliographic compilation of technical information related to the correlation of instrumental measurement and sensory evaluation. Specifically, information is needed in the fields of taste, odor, and visual perception. References and data are needed on any aspect such as sampling, separation, detection, physiology, reconstitution, correlations, practices, applications, etc.

The task group chairmen need help in compiling this information. Anyone having any information—no matter how meager—is requested to send it to one of the following:

Taste.—Dr. W. Stahl, McCormick and Co., Baltimore 2, Md.

Odor.—Dr. Eugene Levy, Atlantic Refining Co., Box 8016, Phila. 1, Pa.

Visual.—Dr. R. W. Shortridge, Midwest Research Inst., Kansas City, Mo.

ISO 27 Solid Mineral Fuels London Meeting

FIVE EXPERTS ON coal and coke from the USA were among the 66 delegates from 15 countries participating in the Sixth Plenary Meeting of ISO 27 in London June 26–30, 1961. Leader of the group was W. H. Ode, U. S. Bureau of Mines; other USA delegates were W. W. Anderson, Commercial Testing and Engineering Co.; W. L. Glowacki, Eastern Gas and Fuel Associates; W. C. McCulloch, Roberts & Schaefer Co.; and J. B. McIlroy, Babcock & Wilcox Co.

Progress to date is impressive, the committee having completed action on 13 ISO Recommendations, approved 8 items for circulation as ISO Recommendations, and circulated 12 ISO Proposals for letter ballot of the committee. Twenty additional drafts are being worked on in the committee.

Subjects dealt with at the meeting included coal preparation, brown coals and lignites, ash and moisture determinations, sampling, and matters relating to coke. The USA group has taken the position opposing alternative methods for empirical tests, and this has influenced the pattern of voting.

As the work on the most important methods of test nears completion, attention is turning to development of a glossary of equivalent terms in the main languages and to the complex problems of sampling.

ISO 61 Plastics To Meet in Turin

OCEAN HOPPING is a commonplace experience for members of the USA National Committee of ISO 61 Plastics who are joining friends from 20 other countries for a week-long series of meetings in Turin, Italy, October 2–7, 1961. Chairman of the USANC is A. C. Webber, ASTM vice-president. The USA holds the secretariat of this international committee, and the presiding officer at the plenary session will be Robert Burns, of the Materials Advisory Board, NAS–NRC. Messrs. C. L. Condit of the Society of the Plastics Industry and H. Warner Dailey of the American Standards Assn. are secretary and assistant secretary, respectively, for the meeting. Others attending are Gordon Kline of the National Bureau of Standards; W. E. Brown, Dow Chemical Co.; G. W. Ingle, Monsanto Chemical Co.; J. B. Howard, Bell Telephone Laboratories; H. C. Gunst, Union Carbide Plastics Co.; E. A. Hafner, U. S. Rubber Co. and representing Manufacturing Chemists Assn.; Samuel Steingiser, Mobay Chemical Co.; and N. A. Skow, Synthane Corp. and representing the Society of Plastics Engineers.

A new Working Group 10 on Cellular Plastics is being organized under the temporary chairmanship of E. A. Hafner. A chairman is to be chosen from one of the other member countries. Two policy documents are being considered—one outlining a procedure for liaison with other ISO and IEC committees and the other a manual of style for ISO Recommendations.

Of the 97 ISO committees, the plastics committee has been most productive, having turned out to date some 12 per cent of the 183 ISO Recommendations now in print. It is continuing a vigorous program, and the members feel that its efforts are contributing significantly to world trade in plastics and to international understanding and good will.

The Atom in Materials Testing Topic for Nuclear Congress

APPLICATION OF atomic physics in tests of materials will be one of the major topics at the 1962 Nuclear Congress and Atomic Exposition, which will be held June 4–6, 1962, in the New York Coliseum under sponsorship of the Engineers Joint Council.

Subjects of other technical sessions will be: public aspects of nuclear use, problems of advanced reactors, nuclear education for engineers, computational problems in the nuclear industry, instrumentation, testing methods, radiochemical separation, fuel cycling, and nuclear safety. Sessions in all areas will be held concurrently on June 5 and 6. June 4 will be devoted to an all-day general session on operating experiences with power reactors.

The Nuclear Congress was established in 1955 and has met annually in conjunction with the Atomic Exposition, most recently in 1960. With the announcement earlier this year by EJC that the next Congress and Exposition will be held in June, 1962, the event has been formally established as a biennial one.

ASTM representative on the Program Committee is M. A. Cordovi, The International Nickel Co., Inc.

1962 CIB Congress

Preliminary information is available on the second CIB Congress sponsored by the International Council for Building Research Studies and Documentation, which will be held September 6–11, 1962, in Cambridge, England.

The theme of the congress will be "the influence of changing requirements and developments in materials and components on design and construction." Sessions will cover general trends in broad geographic areas; how new developments arise; consideration of innovations from the point of view of the builder; assessment and acceptance of new developments; assessment of user satisfaction; and the problems of transmittal of information, particularly to small builders.

The congress will be open to all interested persons, but a maximum attendance will be set in order to provide personal contact between participants, this being one of the main purposes of the congress. Those wishing to register provisionally may write to the General Secretariat of CIB, P.O. Box 299, Rotterdam, The Netherlands. Additional information may be obtained from Dan R. Hamady, Assistant Administrator, Office of International Housing, Housing and Home Finance Agency, Washington 25, D. C.

MATERIALS SCIENCES

Materials in Space

WHAT HAPPENS to nonmetallic materials under extreme vacuum and exposed to severe conditions of ultraviolet and nuclear radiation? To find out, the National Aeronautics and Space Administration has launched an 18-month study with the Martin Co.'s Baltimore division to the extent of $52,000. According to Irvin Kramer, chief of materials research at Martin-Baltimore, the familiar properties of certain materials, such as pliability of rubber, could change completely when exposed in outer space over a long period. The changes in properties of a variety of nonmetallic materials including rubber, plastics, and various synthetic membranes and insulating substances will be studied under vacuum and high-intensity ultraviolet radiation. Specific observations will be made on—

- the loss in weight over a period of time at a certain temperature,
- the type of molecule "evaporated" from the substance,
- changes in the strength and permeability of the material.

The results should enable prediction of useful life of the material in space.

Paint for Space Vehicles—Excess heat is hard to dispose of in a space vehicle because it cannot be convected or conducted away. Therefore, reflecting paints can play a large part in controlling heat. A new kind of paint composed of alkali silicates and high-purity ceramic-type pigments that withstood laboratory exposure of 2000 hr in vacuum and extreme conditions of temperature and radiation was described by Merle E. Sibert of Lockheed's Missile and Space Div. at the Chicago meeting of the American Chemical Society in September. Mr. Sibert told the meeting that such paints are now in orbit on the new American weather satellite, Tiros III. Laboratory tests made prior to the July 12 launching indicate that the paints are capable of maintaining their optical, chemical, and structural stability for extended periods in the space environment.

New Facts from Obscure Element

RESEARCH ON AN element that does not exist in nature has confirmed some fundamental ideas about all chemical elements. New facts learned about the man-made, radioactive element astatine were reported by Evan H. Appelman of the Argonne National Laboratory at the Chicago Meeting of the American Chemical Society in September.

First prepared in 1940 in the University of California cyclotron by Nobel Prize-winner Emilio Segre, astatine is unstable and intensely radioactive, having a half-life of only 8 hr.

Astatine has remained the only obscure member of the well-known halogen family of elements.

Chemists have long wanted more information about astatine, Dr. Appelman said, in order to verify predictions they have made about its properties compared with the other halogens. Principles established in this way can be extended to other families of elements.

"For instance," Dr. Appelman said, "the halogens are classified as nonmetals. In fact, they are the most nonmetallic of all the elements. However, as we go to the heavier members of the group, we find them beginning to act more and more like metals, and this tendency is most pronounced in astatine, the heaviest halogen.

"We may generalize this result and conclude that, other things being equal, the heavier an element, is, the more metallic will its behavior be."

Techniques used in studying the properties of astatine included the incorporation of minute amounts of astatine compounds in crystals of other, closely related halogen compounds, and the distribution of astatine and astatine compounds between layers of water and carbon tetrachloride.

To correlate successfully the trends in properties among the halogens we need a rather thorough knowledge of all members of the group. In the absence of detailed information about astatine, it was difficult to draw reliable conclusions about the halogen family as a whole.

"The chemical elements are of such diverse nature that it is virtually impossible to comprehend the entire spectrum of chemical behavior starting from scratch. It is much more fruitful to look at a group of elements like the halogens, which on the whole are very much alike.

"This simplifies things considerably, and it is usually possible to understand the differences in behavior that do exist within the family in terms of a few fundamental principles. These principles may then be used to interpret the behavior of the rest of the chemical elements."

Water Taste and Odor Study

THE MANUFACTURING Chemists' Assn. is sponsoring a continuing study at The Franklin Institute on taste and odor problems in industrial and public water supplies. A phase of the project has been completed with the publication of the report, "Taste and Odor in Water—A Critical Review," by Robert A. Baker. The report is part of a long-range study to develop information and analytical procedures for measuring taste and odor in public waters.

Mr. Baker is active in ASTM Committees D-19 on Industrial Water and E-18 on Sensory Evaluation of Materials and Products, and the findings in the MCA project will, no doubt, be reflected in ASTM standards for these determinations. The report is available from MCA for $3.50.

Optics and Spectroscopy Available to ASTM Members

ASTM MEMBERS may now subscribe at a special reduced price to *Optics and Spectroscopy*, an English translation of *Optika i Spektroskopiya* from the Russian by the Optical Society of America. *Optics and Spectroscopy* is published in English translation within three months of the Russian edition. The Optical Society of America is making a special offer to members of scientific societies which are cooperating with OSA by joining the "OiS Club." Members of the societies in the "club," which includes ASTM, may subscribe to *Optics and Spectroscopy* at $11 per year. Full information may be obtained from Miss Patricia R. Wakeling, Assistant Secretary, OSA, 1155 16th St., N. W., Washington 6, D. C.

13th Pittsburgh Conference Set for March

THE THIRTEENTH Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, sponsored by the Analytical Chemistry Group of the Pittsburgh Section of the American Chemical Society and the Spectroscopy Society of Pittsburgh, will be held at the Penn-Sheraton Hotel in Pittsburgh, Pa., March 5–9, 1962.

Symposia on chemical analysis of metals, gas chromatography, Raman spectroscopy, spectroscopic studies of polymers, and vacuum spectroscopy are planned. In addition, original papers on all phases of analytical chemistry and spectroscopy are invited. Correspondence regarding papers should be submitted in duplicate to: C. F. Glick, program chairman, The Pittsburgh Conference, Applied Research Laboratory, U. S. Steel Corp., Monroeville, Pa.

NEW ASTM PUBLICATIONS

The Growth of Ice in Supercooled Water

Thirty-fifth Edgar Marburg Lecture, by Bruce Chalmers. Single copies to members on request. Additional copies to members 80 cents. List price $1.

THE STUDY of simple substances often reveals basic principles contributing to understanding of more complex materials. The truth of this statement is amply demonstrated in the observations of Prof. Bruce Chalmers, Gordon McKay Professor of Metallurgy, Harvard University, reported in his lecture honoring the first secretary of the Society, Edgar Marburg. Under some conditions, water may be supercooled far below its usual freezing point, remaining in the liquid state until the critical radius of an aggregate of molecules is reached at the prevailing temperature or until crystallization is triggered by suspended particles or by ultrasonic vibration or friction. Growth of crystals may proceed from a smooth ice surface, as when the flow of heat is through the ice to a heat sink, or growth may be dendritic or tree-like, when heat flow is through the liquid phase. These observations have implications in the formation of other crystalline solids from the melt or liquid phase and are helpful in understanding what happens, say, in zone refining of semiconductors and other problems in metallurgy.

A very practical problem—that of frost heaving—can be understood and eventually solved through knowledge gained from theoretical studies. Prof. Chalmers explains in the lecture how ice lenses are formed, taking into consideration the various factors including supercooling, nucleation, critical molecular radius, and size of soil particles. It is significant that frost heaving does not occur because of the expansion that accompanies freezing; it does occur from the forces drawing water from the surrounding soil building up the size of ice lenses.

Electrodeposited Metal Coatings

ASTM Standards on Electrodeposited Metallic Coatings and Related Finishes, 172 pages, hard cover, price $3.25, to members $2.60.

THE 1961 edition of this compilation of standards includes many new items of particular interest to the electroplating industry. New Specifications for Electrodeposited Coatings of Multilayer Nickel plus Chromium on Steel (B 375) have been developed to permit standardization of the new "duplex" multi-nickel layer coatings under plating for outdoor service where both appearance and protection against corrosion of the basis metal are important. The Recommended Practice for Preparation of Nickel for Electroplating with Nickel (B 343), which was published last year to serve as a guide for producing adherent electrodeposits of nickel on nickel (the duplex nickel process), is also included.

For the first time, a series of definitions of Terms Relating to Electroplating (B 374) appears in this volume. This list of over 200 terms has been reviewed by representatives of the entire electroplating industry and is the culmination of several years of intensive study and discussion.

The new compilation includes four standards covering the anodizing of aluminum metal, formerly under the jurisdiction of Committee B-7 on Light Metals and Alloys. In addition, two new laboratory tests to determine corrosion resistance are included. These test methods, which have been shown to be of particular value in the laboratory testing of electrodeposited metallic coatings, are: Tentative Method of Copper-Accelerated Acetic Acid–Salt Spray (Fog) Testing (Cass Test) (B 368) and Tentative Method of Corrosion Testing of Decorative Chromium Plating by the Corrodkote Procedure (B 380).

Engine Antifreezes

ASTM Standards on Engine Antifreezes, 88 pages, hard cover, price $2.50, to members $2.00.

IN ADDITION to the many revisions of existing standards, this compilation contains four new standards. The new Recommended Practice for Selection of Engine Antifreezes for Use in Automotive Cooling Systems —Ethylene Glycol and Methanol Types (D 1880) is of particular interest to the consumer and to research workers in this field. Through the use of this screening specification, one or more brands of antifreeze may be selected on the basis of certain physical and chemical characteristics as suitable for further investigation. Once this selection is made, it is expected that additional laboratory or service tests will be considered for final evaluation of these antifreezes for use in internal combustion engine cooling systems.

Two additional new standards in this volume are the Method of Glassware Test for Foaming Tendency of Engine Antifreezes (D 1881) and a new physical test method covering a procedure for determining the Effect of Antifreeze Solutions on Organic Finishes for Automotive Vehicles (D 1882).

In addition to the specification for the thermometers used in these test methods, the Specification for ASTM Hydrometers (E 100) will be included to

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specify the hydrometers used in the engine antifreeze tests. The addition of these newly developed procedures and specifications will enhance the value of this publication for both producers and consumers in this field.

Fire Test Methods

STP 301, 82 pages, hard cover, price $3.25, to members $2.60.

FIRE tests of materials used in building construction are performance tests of the highest order. The results, and particularly the interpretation of the results, are related directly to the protection and safety of human life. Committee E-5 on Fire Tests of Building Materials and Construction is a highly qualified group experienced in the development of standard fire test procedures which are nationally recognized.

The symposium, consisting of four papers, was presented in a session under the sponsorship of Committee E-5 during ASTM Committee Week in Cincinnati, Ohio, February 1, 1961. The committee hoped, through this medium, to present a series of papers relating to fire test procedures with a minimum of emphasis on the particular merits of individual proprietary products.

From a historic viewpoint, the first paper by Harry Shoub, National Bureau of Standards, presents interesting information on the pioneer attempts to simulate actual conditions in a burning structure. The testing of building structures for their endurance in fire was necessitated by the rise of skeleton-type construction in the last years of the 19th century. The need for a fire-resistant covering for the protection of iron, and later steel, columns also contributed to the need for proper tests.

The problem of predicting fire test results is discussed in a paper by T. Z. Harmathy, National Research Council of Canada. Fire endurance ratings have long been a point of discussion and argument as applied to individual materials and constructions. Mr. Harmathy describes a numerical method for solving one-dimensional transient heat flow problems of any complexity.

The scarcity of fire resistance information led to the development of a fire research laboratory by the Portland Cement Assn. which is outstanding in its design and flexibility. A new beam furnace is described in a paper by C. C. Carlson and P. J. Tatman, both of PCA, as well as some experience gained from its use. This installation is used primarily to study the many new types of structural elements now being manufactured by the precast concrete industry.

The final paper in the symposium consists of a survey of test methods and comparison of results when measuring surface flammability of materials. The author, J. A. Wilson, Factory Mutual Engineering Div., describes ASTM Method E 84, commonly known as the "tunnel test," developed at the Underwriters' Laboratories; the radiant panel test developed in this country at the National Bureau of Standards and now published as ASTM Tentative Method E 162; and a test method known as the "small tunnel test," developed at the Forest Products Laboratory and originally considered as a small-scale model of the "large tunnel test" (E 84). Several other small-scale test procedures are reviewed, including the Schlyter test, originally developed in Sweden; the Factory Mutual test; a procedure known as the Spread of Flame Test, used by the British Joint Fire Research Station; and a Building Board Test, also developed by the British Joint Fire Research Station.

The contents are:

Early History of Fire Endurance Testing in the United States—Harry Shoub, Fire Research Section, National Bureau of Standards, Washington, D. C.

A Treatise on Theoretical Fire Endurance Rating—T. Z. Harmathy, National Research Council, Fire Section, Division of Building Research, Ottawa, Ont., Canada.

The New Beam Furnace at PCA and Some Experience Gained From its Use—C. C. Carlson and Phil J. Tatman, manager and senior research engineer, respectively, Fire Research Section, Portland Cement Assn., Skokie, Ill.

Surface Flammability of Materials: A Survey of Test Methods and Comparison of Results—J. A. Wilson, chief construction engineer, Factory Mutual Engineering Div., Norwood, Mass.

ACR NOTES ADMINISTRATIVE COMMITTEE ON RESEARCH

Communications

By J. C. Harris[1]

"COMMUNICATIONS" here will be considered as "getting the message" to others. The larger the audience, or the greater the volume of literature, the more necessary exact communications become. The various forms of getting a story across to people at many levels of intellectual training require clear, precise wording interpretable only as the author wished. This apparently simple objective is not easy to accomplish, nor is it generally achieved, as the numerous collegiate and business courses on this subject appear to indicate.

Clarity in not only written, but also oral presentation is necessary if a point is to be grasped exactly. The difficulty in communicating precisely and clearly is readily recognized if one is deprived of voice inflection, gestures, and crutches such as "gadget," "thing-a-mijig," and other sloppy descriptive habits. The problem with written communications is at least as difficult, and many notices, orders, directives, and the like fail entirely to make their points, frequently because they are too verbose. With the rapid increase in volume of publication, reviewers and editors alike are confronted with the need for space economy. This means that manuscripts, particularly on technical subjects, must be concise and clear. For the author this frequently imposes extensive rewrite work, both for condensation and for clarity.

Specification writing is an especially difficult art, whose aim is to attain a specific end result without need for further interpretation. ASTM methods and specifications are essentially nearly ideal forms of "communication." With an economy of space they unambiguously define the subject, give the procedure, indicate limits and precision, and show how to report results. To take part in the preparation of methods or specifications is a broadening experience not gained even by attendance at courses designed to show how these "communications" can best be achieved. Committee work and the preparation of standards are an education in themselves, and are recommended to all technical people. ASTM committee members show the benefit of this education in their own reports and publications. Education in "communications" is only another of the many benefits of committee activity.

[1] Manager, Application Research, Monsanto Research Corp., Dayton, Ohio.

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COMING MR&S PAPERS

Corrosion of Stainless Steel in the Presence of Concentrated Nitric Acid—Ch. Apert and Mme. Vialatte, Centre d'Essais des Propulseurs.

The Scientific Application of Particle Accelerators to Nondestructive Testing—E. A. Burrill, High Voltage Engineering Corp.

A Nomographic Procedure for the Detection of Suspect Unconfined Compressive Strength Values in a Series of Soil-Additive Strength Determinations—H. T. David, D. T. Davidson, and C. A. O'Flaherty, Iowa State University.

Effects of Variables in Charpy Impact Testing—N. H. Fahey, Watertown Arsenal Laboratories.

Apparatus for Obtaining Mechanical Properties at High Temperatures—D. H. Fisher, R. L. Carlson, and F. C. Holden, Battelle Memorial Inst.

Stress-Relaxation—Some New Test Methods for the Determination of This Mechanical Property Either in Tension or in Compression—G. R. Gohn and A. Fox, Bell Telephone Laboratories, Inc.

The Bend-Test Properties of 43XX-Vanadium Modified and 5 Per Cent Chromium Sheet Steels—E. P. Klier, George Boras, and Jane Jellison, Catholic University of America.

Sinusoidal-Strain Dynamic Testing of Rubber Products—A. R. Payne, Rubber and Plastics Research Association of Great Britain.

Improved Adiabatic Calorimeter for Concrete—David Pirtz, University of California.

A Statistical Comparison of the Wearing Characteristics of Two Types of Dollar Notes—E. B. Randall and John Mandel, National Bureau of Standards.

Tensile Impact Testing of Plastics—R. F. Westover, Bell Telephone Laboratories, Inc., and W. C. Warner, The General Tire and Rubber Co.

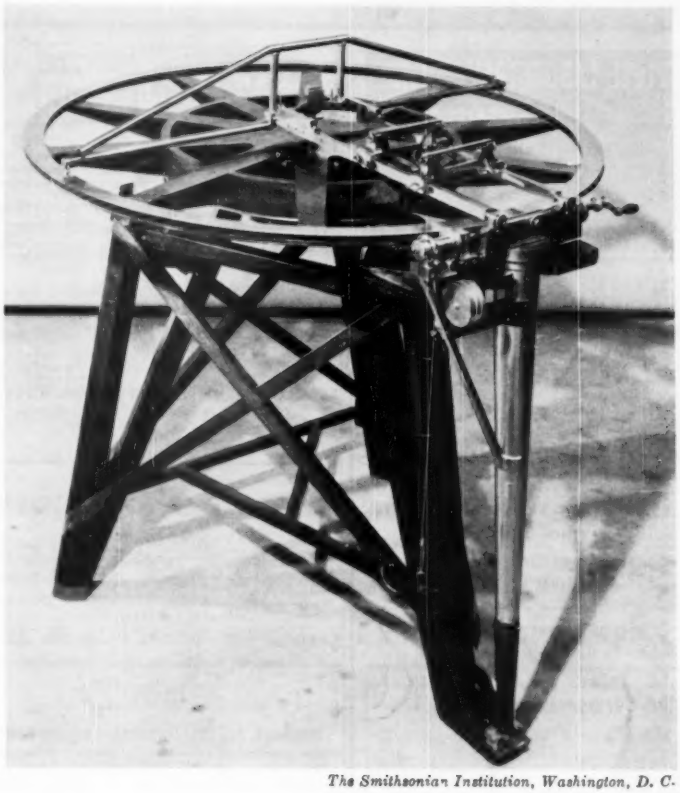
Experimental Design and ASTM Committees—W. J. Youden, National Bureau of Standards.

Information Processing Congress To Be Held in Munich

THE INTERNATIONAL Federation of Information Processing Societies will hold a Congress in Munich, Germany, Aug. 27–Sept. 1, 1962. Papers, symposia, and panel discussions will cover such topics as: business and scientific information processing, real time information processing, storage, and retrieval of information, language translation and linguistic analysis, digital communication, artificial perception and intelligence, advanced computer techniques, and education.

In each category it is planned to cover, where appropriate, the applications of digital computers, programming, systems design, logical design, equipment, and components. Further information can be obtained from E. L. Harder, Westinghouse Electric Corp., East Pittsburgh, Pa.

Ramsden's Dividing Engine



The Smithsonian Institution, Washington, D. C.

JESSE RAMSDEN (1735–1800), son of a Yorkshire innkeeper, apprenticed himself to a London instrument maker. Partly through his own prodigious mechanical skill and partly through marrying the daughter of John Dolland, greatest of the profession, he rose to the top of his trade and remained there despite a notorious disregard for time and deadlines, which impeded his quest for meticulous precision. The first and most fundamental problem of accurate instrument making had long been recognized—that of replacing the slow and uncontrolled process of geometrical division of arcs by some mechanical device. Ramsden solved the problem with great ingenuity, first by producing a precision screw, then by using it to cut teeth on a great wheel. His second engine (the first to be satisfactory) was made in 1774–1775 and is now preserved at the Smithsonian Institution. So accurate are its divisions that even the best modern instruments can detect no significant error greater than that with which engraved lines can be cut or read.

Text by Professor Derek J. de Solla Price, Yale University. Copyright; text and photographs reproduced by permission of Professor Price and Arthur D. Little, Inc.

LETTERS

Explosion Age

¶ Your editorial on The Explosion Age expresses perfectly the basic problem of our generation—or should we say this fraction of our generation.

I have often wondered where man would be if he directed as much money and effort toward social progress as he does toward scientific progress.

WILLIAM K. WILSON,
McLean, Va.

¶ I wish to congratulate you on the excellently prepared editorial article contained in the August, 1961, issue.

JOHN J. B. RUTHERFORD,
Chief Metallurgist,
The Babcock & Wilcox Co.

¶ Your editorial, "The Explosion Age," in the August, 1961, issue is thoughtful and provocative. I'd like to reprint it in *Texas Industry*. We would, of course, give proper credit.

May we?

OPAL HILL MUNZ,
Editor, *Texas Industry*

[*Yes.*—Ed.]

¶ May we have permission to reprint, in *The Chemist*, your editorial in the August, 1961, issue entitled "The Explosion Age?"

VERA F. KIMBALL,
Editor, *The Chemist*

[*Yes.*—Ed.]

Hydrogen-in-Titanium Samples Now Available from NBS

THREE NEW gas-in-metal standard samples—of titanium containing three different levels of hydrogen (32, 98, and 215 ppm)—are now available from the National Bureau of Standards. These reference materials are part of a series begun in 1959 to provide standards of gases in a variety of metals. Such standards are useful for calibrating chemical analytical equipment used to measure the gas content of alloys. The first samples of the series, eight bars of iron and low-carbon steels, are certified for their oxygen and nitrogen content.

Because the usefulness of titanium alloys increases with decreasing gas content, improved specifications limiting the amount of gases present are needed, especially for those titanium alloys used in rockets and missiles. These standard samples will help in the monitoring of the gas content of such materials.

The standards may be purchased for $10 per sample from the Standard Sample Clerk, National Bureau of Standards, Washington 25, D. C.

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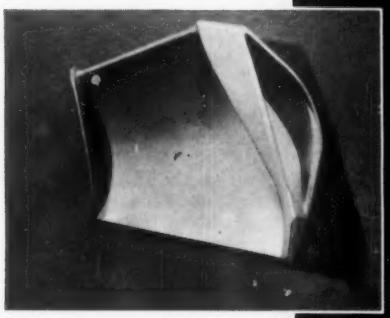
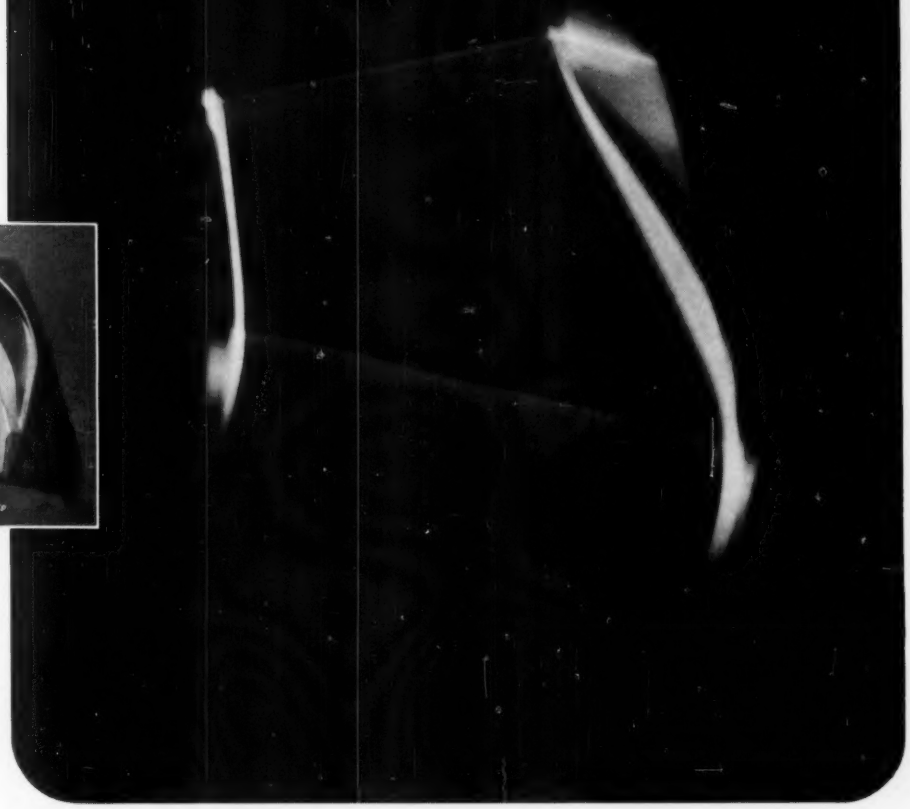


Casting of nozzle guide vane for turbo-jet engine



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Nozzle guide vanes in turbo-jet engines must withstand fiery blasts — dependably. Austenal Company, division of Howe Sound Company, checks the soundness of each cast vane with radiography

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BOOKSHELF

Members who wish to be considered for reviewing books are invited to send in their names and subjects in which they are interested. Due to customs and mailing considerations, requests from the United States only can be considered. Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

Quality Control and Applied Statistics Including Operations Research Yearbook 1960

Interscience Publishers, Inc., New York, N. Y. (1960); 1369 pp.; $60.

Reviewed by Acheson J. Duncan, The Johns Hopkins University.

THIS IS THE collection of abstracts published during 1960 as *Quality Control and Applied Statistics Abstract Service*. The original papers were generally published in 1959 and the first half of 1960. The number of journals reviewed are not recorded in the current volume, but the original abstracting service listed something like 350, American and foreign.

The abstracts aim to do more than those conventionally published in that they are much more extensive. They generally contain original data, graphs, charts, photographs, etc., which may relieve the case worker from the necessity of referring to the original articles. The abstracts follow a pattern of first stating in a single sentence the purpose of the article abstracted, then presenting a very brief (say five-line) summary, and finally giving a one- or two-page digest of the results. A sampling of the abstracts indicates that they are well written.

The bound volume contains a table of contents that classifies the abstracts under the following general headings: statistical process control, sampling principles and plans, management of quality control, mathematical statistics and probability theory, experimentation and correlation, managerial applications, measurement and control, and reliability of complex assemblies. Each division includes several subheads; some of the more important are experimental designs, curve fitting, and operations research. In addition, the volume contains an author index and a 17-page subject index.

When members of a company or small college do not have ready access to quality control and statistical journals, this Interscience abstract service may be invaluable. It should be noted, however, that much less expensive, but much briefer sets of abstracts on statistical theory and application are published by the International Statistical Inst. These more concise abstracts are sufficient to indicate the nature and contents of the article abstracted, but they cannot conceivably be viewed as a substitute for the original articles, as can the Interscience abstracts.

Response of Metals to High Velocity Deformation

Edited by P. G. Shewmon and V. F. Zackay; Interscience Publishers, Inc., New York, N. Y. (1961); 504 pp.; $18.00

Adapted from Preface.

THIS BOOK contains the Proceedings of a Technical Conference sponsored by the Physical Metallurgy Committee of the Institute of Metals Division, The Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers. The Technical Conference was held at Estes Park, Colorado, July 11 and 12, 1960.

The purpose of the conference was three-fold: first, to compare notes on experiments already performed but not published; second, to try to pin down the major problems which are impeding understanding of the effects; and third, to educate a considerable number of amateurs who were anxious to obtain a beginning knowledge of this subject.

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ASM Review of Metal Literature, 1960 (Volume 17)

Edited by Marjorie R. Hiplop; published by American Society for Metals, Metals Park, Ohio (1961); 1342 pp.; $25.

Adapted from publisher's description.

THIS CLOTH-BOUND book contains nearly 12,000 annotations of articles, technical papers, reports, and other documents appearing in engineering, scientific, and industrial journals and books throughout the world during 1960. The book is divided into 20 sections covering different areas of materials and process engineering and technology and includes addresses of publications as well as comprehensive subject and author indexes.

Back issues of Volumes 1 through 16, 1944–1959, are available at $20.00 per copy.

High Speed Testing, Vol. 2

Second Annual Symposium held at Boston, Jan. 27, 1961; Interscience Publishers, Inc., New York, N. Y. (1961); 78 pp; illus.; $4.50.

Reviewed by G. R. Irwin, U. S. Naval Research Laboratory, Washington, D. C.

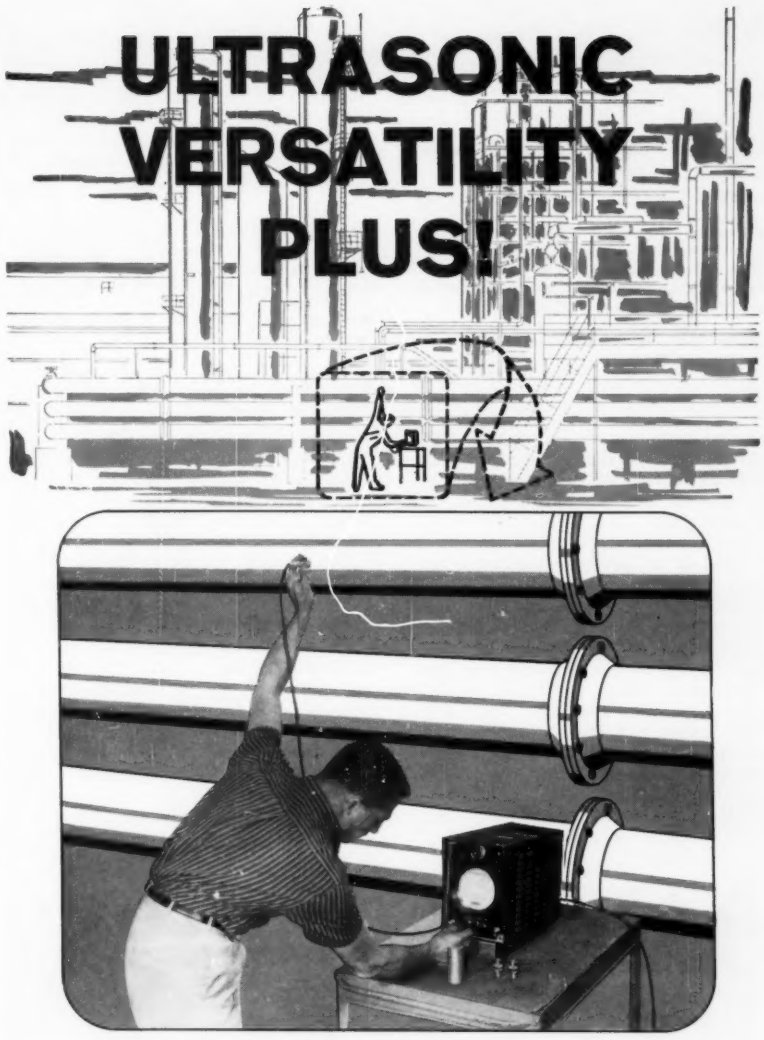
THIS VOLUME contains eight lectures on various topics in the field of high-speed testing. These discuss methods of dynamic testing and analysis for metals, filled rubbers, solid polymers, textiles, films, and instruments. Individuals confronted with new tasks which require high-speed testing do not, in general, find past technical experience adequate for their guidance. Such experience is, nevertheless, helpful, and the contents of this book will be of substantial assistance.

The first lecture (Bills, Sweeney, Salcedo) grapples with the task of representing mechanical characteristics of a filled rubber in which loosening of filler particles from the matrix has an appreciable influence upon mechanical properties. A discussion of the Duhamel or confluence integral approach is given in the second lecture (Berger). The fifth contribution (Jones) and the last lecture (Krafft) discuss the high-speed machines most likely to be used by investigators who need maximum control either of strain rate or loading speed. In each lecture the authors' ideas are given factual illustration with measurement data.

The large page size of the book, 8 by 10½ in., allows ample space for illustrations containing considerable detail. Illustrations of the line-drawing type are well done. With a few exceptions the photographic illustrations lack clarity. The book contains a table of contents but no subject index.

As noted in the preface (Eirich), a review of the topic, high speed testing, particularly for strain-rate-sensitive materials, is of distinct value even though without pretense of being all-inclusive.

(Continued on p. 830)



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(*Continued from p. 829*)

Causes of Variation in Chemical Analyses and Physical Tests of Portland Cement

By Leonard Bean and J. R. Dise, National Bureau of Standards Monograph 28 (April 27, 1961); 24 pp.; 25 cents (Order from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.)

Adapted from publisher's description.

THIS MONOGRAPH LISTS and discusses many of the causes for variation in chemical analyses and physical test results in comparative tests of portland cements and suggests remedies for some of the more frequently encountered deficiencies in apparatus and methods.

Many of the organizations engaged in the testing of portland cements have found it advantageous to use frequent interlaboratory tests on carefully prepared samples of the material in order to evaluate the performance of the laboratories involved. Laboratories participating in these comparative tests have reported their results. Variations which could lead to the rejection of material fully conforming to specification requirements or to the acceptance of material with undesirable chemical or physical properties thus become apparent, and the causes of these variations are the main subject of this monograph.

Particular consideration is given to problems which do not seem to have been covered in sufficient detail in previous discussions of cement testing procedures. Literature references are given for additional information.

Plastics in Nuclear Engineering

By James O. Turner; Reinhold Publishing Corp., New York, N. Y. (1961); 139 pp.; $5.50.

Reviewed by Donald J. Metz, Brookhaven National Laboratory.

THIS BOOK is stated to be "... addressed primarily to engineers, designers, students, and in fact to all practical people in plastics ..." and claimed to cover "... discussions of a number of plastics applications that have been of value in the nuclear field..." With this as a yardstick against which to measure its success, it is the reviewer's opinion that, in some respects, the book fulfills these promises, while in others it falls short of this aim.

The casual reader will not only become acquainted with some of the important roles that plastics play in making much of our nuclear technology possible, but he will also learn about many of the interesting fields that comprise that technology. In this regard, the book seems to serve the dual purpose of whetting the appetite of the uninitiated to learn more about this entire field and stimulating those who are in the field by acquainting them with novel applications and suggestive implications.

The organization of the diversified areas covered seems to follow a logical pattern. The book is amply illustrated for its size (45 illustrations), and the index is reasonably well cross-referenced and representative.

The bibliography, however, falls far short of what might be expected, especially in view of the many interesting applications described and alluded to in the text. For instance, 33 per cent of the bibliographic references are germane to the scant 10 per cent of the text devoted to "Effects of Radiation" (Chapter 10). On the other hand, no literature references are given for any of the applications discussed.

It is the reviewer's opinion that a much greater effort should have been expended to include complete literature references to specific applications. This shortcoming is a serious limitation to the ready applicability to designers and engineers of much of the technology described. As a result, the engineer and designer who reads about an application in which he may be seriously interested is left to ferret out the original sources of information.

National Building Code of Canada, 1960

Associate Committee on the National Building Code, National Research Council, Ottawa, Canada (1960); $4.

Reviewed by L. C. Gilbert, ASTM Staff.

THE UNIFORMITY of building regulations on a national scale is the goal of all who are intimately connected with regulations governing the construction industry. In Canada, much progress has been made in this direction through the publication and wide acceptance of the National Building Code of Canada.

The third edition of this code is now available. In contrast to some of the older and archaic massive code volumes, this publication presents a very compact and concisely arranged compendium of information on building construction regulations. The book is divided into nine parts, each complete in itself, with a minimum of cross reference. These nine parts contain all the necessary phases of a code including such important sections as definitions, design, materials, use and occupancy, and construction safety measures.

Of particular interest, of course, to ASTM members is the extensive use as references of ASTM standards. ASTM methods of tests are used almost universally through the entire range of materials. Part 5 on Materials contains a concise listing of all references to materials and testing standards. In addition, other parts containing sections on materials include a convenient reference to standards.

All ASTM standards listed in this Code are found in the Special Compilation of ASTM Standards in Building Codes.

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Although a number of positive-ion accelerators have been installed specifically for this kind of developmental work, we believe that the use of particle beams for *materials evaluation* is just getting started, and that many programs are dormant because of the cost and skill-requirement of owning and operating an accelerator facility.

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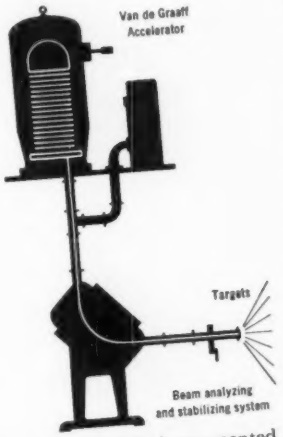

The facility is fully instrumented, including a 200-channel pulse height analyzer for scintillation spectrometry and decay-scheme studies, a remotely-operated sample changer, and neutron moderator.

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D-D	1.5-6*	5×10^9
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MATERIALS AND TESTING TOPICS

This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

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Potentiometer—A new molded plastic terminal header now incorporated in ½-in. precision potentiometers withstands temperature extremes to 500 F and maintains a tight seal under severe humidity conditions. The plastic material is approved under specification MIL-M-18794SDG.

Ace Electronics Associates, Inc. 3903

Gas Sampler—Extremely quiet and completely free of lubricants or other gas stream contaminates, the DIA-PUMP is used as a sampling pump, to operate vacuum pickups, aerate liquids, and power dehydration systems. Model G-5 DIA-PUMP is available with type 316 stainless steel compression heads and inert diaphragms for handling corrosive gases.

Air Control, Inc. 3904

Manipulators—Development of remote handling tongs with new continuous locking action and parallel-motion jaws is announced. Use of this equipment promises safer handling of explosives, radioactive substances, and toxic materials. These relatively inexpensive tongs can do almost anything that can be done by hand, including: lift beakers, handle "hot" material, flick switches, pour fluids, and mix chemicals.

Ameray Corp. 3905

Chromatography Supplies—A column packing consisting of Dow Corning QF-1 silicone coated on Gas Chrom P has been found useful for steroid analyses and particularly for separation of cholesterol/cholestanol mixtures.

Applied Science Laboratories, Inc. 3906

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Associated Research, Inc. 3907

Strain-Gage Conditioner—The New B & F Model 1-400 Servomatic modular strain gage and transducer input conditioner will accommodate any type of resistance strain gage or transducer. Each module contains its own individual floating power supply. The servomatic system will null to ± 10 μv.

B & F Instruments, Inc. 3908

Measuring Head—A ¾-in. extruder measuring head for the Plasti-Corder, newest of a variety of attachments, is designed to measure and record torque required to process polymers under a wide range of screw speeds and barrel zone temperatures. It will supplement the Plasti-Corder's other polymer measuring heads in the measurement of factors which affect the processability of all polymers, both plastics and rubber.

C. W. Brabender Instruments, Inc. 3909

Calorimeter—This unit provides the laboratory technician with an apparatus for determining mean specific heat. The unit as manufactured uses ASTM Method C 351 as a reference.

Custom Scientific Instruments, Inc. 3910

X-Ray Diffractometers—Two programming systems for X-ray diffraction equipment are being built. Each system is designed to perform four major functions. First, it will provide positioning commands. Second, it will convert the analog position of the diffraction unit into digital data in terms of degrees, tenths of degrees, and hundredths of degrees. Third, it will control the counting, noncounting, and reset of a five-digit scaler in response to control codes extracted from the input paper tape. Fourth, it will provide a printed and/or punched paper tape record of the diffraction unit position and the scaler count.

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Eastman Kodak Co. 3913

(Continued on p. 834)

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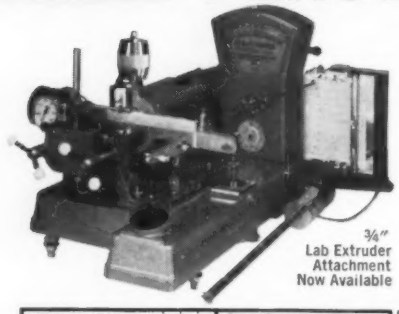

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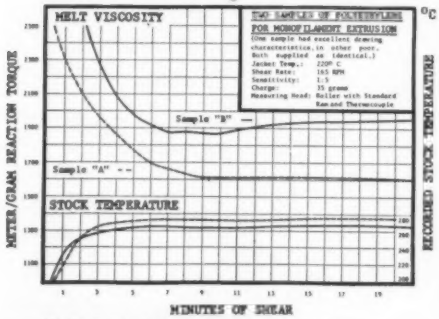

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With over 25,000 in use throughout the world today, we find only one trouble with the Cenco Lab Jack. It lasts too long.

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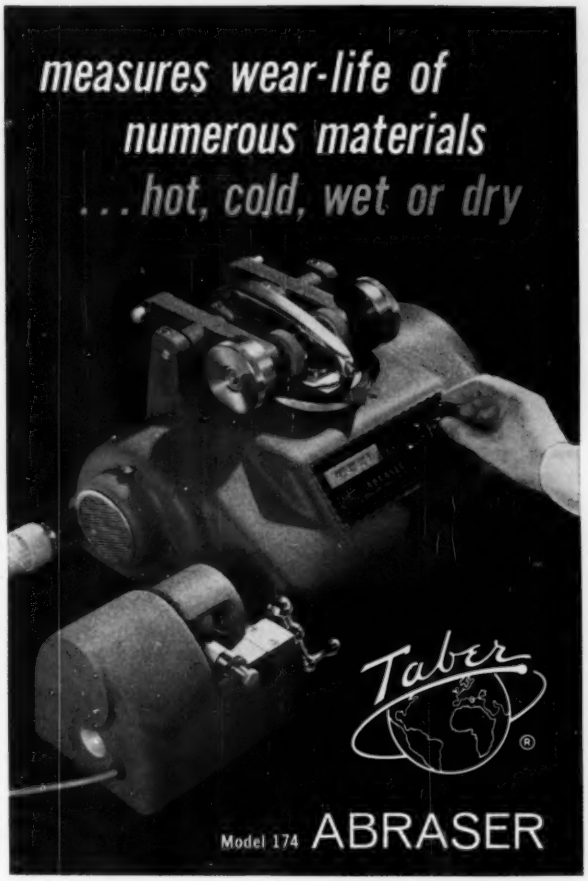

Has hundreds of applications: plastics, paints, lacquers, electroplating, textiles, metals, leather, rubber, linoleum, etc. Easy-to-operate, the Taber Abraser simulates actual wear conditions. A rotary rub action is applied by dual abrading wheels . . . one rubbing the specimen from the center out and the other from the outside toward the center. With the specimen rotating full circle, abrasion resistance is revealed at all angles relative to the material's weave or grain.

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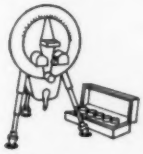
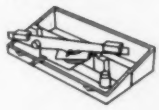
Determines *initial stiffness, basic stiffness* and *resilience* of flexible materials (up to ⅛" thick) such as metals, plastics, paper, boxboard, cellophane, wire, and metal foil.



SHEAR/SCRATCH TESTER

Tests ability of plastics, plastic coatings and organic materials (up to ¼" thick) to resist digs, scrapes, etc., not classed as normal wear.



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FOR THE LABORATORY

(*Continued from p. 832*)

Electron Microscope—New Fisher JEM-6A electron microscope can heat, chill, or subject a specimen to stress, and take motion pictures of moment-by-moment changes. Magnification to 200,000×.

Fisher Scientific Co. 3914

Vacuum Pump—A new low-cost pump to provide a quiet, reliable source for 1 cu ft per min vacuum and pressure, the Model 13152 vacuum/vacuum-pressure pump, is a compact unit ideal for laboratory operation. Easy-to-read vacuum and pressure gages are located on the pump itself. Built-in moisture eliminators aftercoolers, pulsation chambers, intake filters, vibration mounts, and mufflers create a maintenance-free unit.

Gelman Instrument Co. 3915

Coaxial Connectors—New versions of the familiar Type 874 coaxial connectors include locking cable and panel and recessed locking panel types. Retaining the hermaphrodite feature of the standard 874's, the new locking connector is fully compatible with the nonlocking types. When two locking connectors are mated, the threaded sleeve of either connector is screwed onto the threaded shell of the other. The sleeve of the second connector is backed off to a storage position.

General Radio Co. 3916

Refrigerator—This new small 2 cu ft refrigeration machine provides dependable, flexible service for metal treating, shrink fitting, or environmental testing. Model 2L-2-075 needs only connection to facilities to start operation. The Cascade refrigeration system holds −130 F within 1 F dependably.

Harris Manufacturing Co., Inc. 3917

Wire Fatigue Tester—A new model of the Hunter 802 rotating-beam fatigue tester incorporating many design improvements has been announced. The tester's electronic control circuit has been completely redesigned for increased sensitivity and operator convenience. Only one tube is employed, a thyratron, and its sensitivity is adjustable. The fatigue tester accommodates wire specimens from 0.004 to 0.030 in. in diameter.

Hunter Spring Co. 3918

Space Simulator—A space simulation chamber capable of duplicating the atmospheric conditions thought to exist 1000 miles above the earth's surface has been developed. In addition to ultra-high vacuum, the new Ilikon space simulator can duplicate the space conditions of thermal and ultraviolet radiation and can produce temperatures from −300 to +4500 F. The simulator is also designed to permit the introduction of both high- and low-speed motion.

Ilikon Corp. 3919

Nitrogen Analyzer—This nitrogen analyzer has been extensively tested and has proven highly satisfactory for the determination of nitrogen in such materials as titanium nitride, silicon nitride, bonded silicon carbide, molybdenum metal, boron nitride, chromium nitride, zirconium boride, and aluminum nitride. The unit significantly reduces the time necessary to perform this analysis without sacrifice of accuracy or precision.

Laboratory Equipment Corp. 3920

Kryomats—Ultra kryomats are thermostatically controlled circulating refrigeration systems. They develop a high cooling capacity and can be used to dissipate large heat volumes, that is, exothermic reactions, low-temperature distillations, continuous electrophoresis, etc. The solution in the reservoir is refrigerated to an accuracy of ±1 C (floor models) or ±0.2 C (table models). The chilled liquid is then circulated through the control area by duplex circulating pumps which provide both pressure and suction.

Lauda Instruments, Inc. 3921

Horizontal Zone Refining—A new horizontal zone refining attachment for the floating zone and crystal pulling fixture is particularly helpful in research and development laboratories conducting experimental work related to materials science. This new horizontal zone refining attachment is easily mounted on the original basic unit containing the traverse and programming mechanism. The

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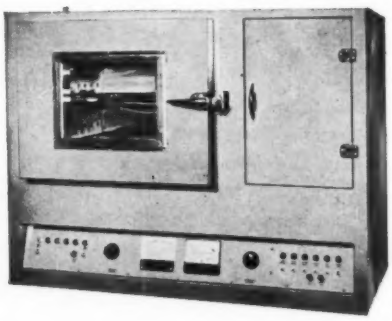
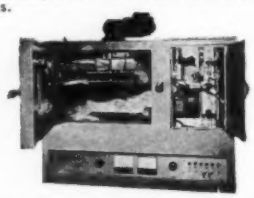


Orec 0300 Series employ an *electronic-chemical loop feed back servo system to achieve and precisely maintain chamber ozone concentrations.



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control panel on the basic unit also operates the induction generator.

Lepel High Frequency Laboratories, Inc. 3922

Helium Refrigerator—The ADL-Collins helium refrigerator is a complete low-pressure installation which may be used to provide cold gas refrigeration at temperatures as low as 8 K to an external load. This unit may also be used for liquefying helium when no refrigeration is required.

Arthur D. Little, Inc. 3923

Furnace—The Dyna-Trol furnace has been designed and constructed for special use in research and laboratories. It is a small, compact furnace which heats up to 2000 F in 1 hr; 2300 F in 1½ hr. A constant level of temperature and infinite heat-rate control ranging from 300 to 2300 F can be maintained by input controllers.

L & L Manufacturing Co. 3924

Horizontal Vibration—A new series of horizontal vibration test fixtures redesigned to increase maximum usable frequency by 60 per cent has been designated the Vibraplane and is available in four models with table dimensions of 20 by 20, 30 by 30, 40 by 40 and 48 by 48 in.

MB Electronics 3925

Strain Gage—A new, flexible, ultra-thin semiconductor strain gage featuring a U-shaped configuration with leads on the same end is now available. The gage, designated Micro-Sensor Model MS632-120, provides greater advantages in higher operating temperatures, stability, flexibility for reduced radii applications, and ease of limited area installation. This U-shaped gage is proof-tested to 3000 microinches, and has an ultimate strain capacity of 5000 microinches.

Micro Systems, Inc. 3926

Proving Ring—The largest-capacity proving ring every made to the National Bureau of Standards' specifications has been introduced. It is capable of measuring compression forces up to 1,200,000 lb to accuracies well within 0.1 per cent of applied load. It was produced to meet the need for greater accuracy in calibrating large-capacity load cells, testing machines, and rocket thrust stands. The ring, which is 30½ in high and weighs 625 lb, has the standard deflection-measuring apparatus consisting of a micrometer screw and a vibrating reed.

Morehouse Machine Co. 3927

Detector System—PC-22 is said to be the first single-detector proportional counting system able to sense and precisely count both alpha and beta radiation independently and simultaneously from the same sample. The all-transistorized system consists of a universal shield with gas flow proportional counter detector, and two decade scalers—one to count and register each type of radiation.

Nuclear Measurements Corp. 3928

Calibrator—An extensometer and recorder calibrator for checking the accuracy of strain measuring instruments, electronic of mechanical recorders, differential transformers, and other precision measuring

(*Continued on p. 836*)

THE MARQUARDT TM-1 A FULLY AUTOMATIC TEST MACHINE

The Marquardt TM-1 Autodynamic Elevated Temperature Test Machine is a fully automatic, servo-controlled universal testing machine which measures and records modulus, yield, ultimate strength, and other mechanical properties of materials.

- *The TM-1 automatically* simulates stress and strain conditions to calibrate recorders, eliminating errors and time consuming setup procedures and data reduction.
- *The TM-1 automatically* runs the test per pre-set conditions.
- *The TM-1 automatically* records the test results in the form of a true stress-strain (psi vs. in/in) curve to failure.
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- *The TM-1 automatically* heats (and controls the temperature of) the test specimen.

Tests can be run automatically under rapid heating and loading or straining conditions at temperatures from −300°F to +5,000°F; with true gage length strain control from .002 in/in/min to 45 in/in/min for 1 in. gage lengths; from 50 gm. to 50,000 lb. in tension or compression. Load and strain control include uniform rate, cyclic, or complex programs.

Now in production and designed to meet today's most exacting materials testing requirements, the TM-1 is only one of the testing tools in Marquardt's product line which includes other universal testing machines, programmers, power controllers, extensometers, and related equipment.

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CORPORATE OFFICES, VAN NUYS, CALIFORNIA

TM-1 CONTROL CONSOLE

TM-1 50,000 LB TEST BED

FOR FURTHER INFORMATION CIRCLE 1280 ON READER SERVICE CARD

FOR THE LABORATORY

(*Continued from p. 835*)

devices has been developed. With this instrument, any linear measurement from 0.005 to 1 in. can be dialed to within 0.00005 in. Rotation of the graduated dial, which is connected to a micrometer screw, moves the upper part of the two-section spindle.

Tinius Olsen Testing Machine Co. **3929**

Liquid Scintillation Counting—Important changes in the line of Tri-Carb liquid scintillation spectrometers have been made. The new line of instruments includes models for both semiautomatic and automatic sample changing and provides for either refrigerated or non-refrigerated operation.

Packard Instrument Co. **3930**

150-Curie Industrial Unit—A 150-c mobile cobalt unit, Tech Ops Model 520, that can be used for directional or panoramic industrial inspection is described as ideal for foundries and steel fabricators in high-production radiography of heavy sections. Model 520, using the 150 c source approved by the Atomic Energy Commission, requires an exposure time only 7 per cent of that required with a 10-c source. The powerful model is designed as a directional unit that can be adapted for panoramic use simply by removing a plug in the source container and adding guide tubes. The source then can be cranked out by remote control. Safety locks and warning lights ensure complete safety.

Picker X-Ray Corp. **3931**

Power Regulator—This compact, solid-state, variable power regulator, the LabAC, regulates power levels up to 4.6 kw yet weighs only 7½ lb and requires less bench space than a telephone. As an economical replacement for a motor-driven variable transformer or saturable core reactor, it may be used for either manual adjustment or automatic control of a-c voltages up to 230 v. Its output is smoothly variable from zero to full power in response to a 0 to 5 ma control signal (power gain in excess of one million).

Research, Inc. **3932**

Portable pH Meter—New Electrion II line-operated portable pH meter features a ±500 mv scale and a unique, full-range shock-resistant combination electrode. Standard features include: constant-reading meter; amplifier-stabilized, drift-free indicator needle; reference pointer; and easily connected solid ground.

Sel-Rex Corp. **3933**

Generators—Two new electrostatic generators, Models AK600-4 and AKS600-4, designed for applications where accuracy and close regulation of output voltage are critical, are rated at 600 kv, 4 ma. The high-voltage power supplies can be used for industrial and research applications including nuclear physics, electron microscopy, cable and insulation testing, mineral separation, condenser bank charging, and electrostatic precipitation.

SAMES (Société Anonyme de Machines Electrostatiques) **3934**

Bearing Test Apparatus—The first bearing test apparatus for measuring radial play in ball, roller, and self-aligning bearings is now available. The gage registers in increments of 0.0001 in.

Southwest Products Co. **3935**

Melting Furnace—Two new Stokes vacuum furnaces are available: an induction melting furnace with a capacity of 50 lb designed for research and development work or small-quantity production, and a cold-wall resistance heat-treating furnace of medium size, capable of operating at temperatures up to 1650 C (3000 F).

F. J. Stokes Corp. **3936**

Humidity Test Unit—A new temperature-humidity environmental test unit providing test space of 5.1 cu ft in a compact cabinet, called Model TMTH-0200, is designed for MIL-E-5272C, MIL-STD-202B, and MIL-STD-170 testing. It provides temperatures from 0 to 200 F and relative humidity from 20 to 95 per cent in the dry bulb range, limited only by 35 to 185 F dew point.

Tenney Engineering, Inc. **3937**

Laboratory Positioner—A new universal positioning device for all-around laboratory use, standing on a firm 9½-lb base, is used to hold laboratory apparatus at any desired point in space and in any direction over the bench or table. Stable enough to hold a 5-lb load with its arms fully extended at an angle of 45 deg, the device is self-clamping over the edge of the table to hold even larger loads.

Henry Troemner, Inc. **3938**

Cracks, Flaw and Leak Detector—The Seal-Lock fluorescent detector is a new, highly sensitive method for finding the most minute hairline cracks as well as straight-through leaks in such materials as aluminum, copper, plastics, stainless steel, and other metals. Portable one-man operation makes the detector ideal for spot inspections in the field as well as volume production inspection.

United States Casting Repair Corp. **3939**

Pyrometer—Portable, battery-powered Williamson pyrometer (radiometer) senses, without touching, critical temperatures of plastics being extruded, paper or fabrics being coated, calendar rolls, inaccessible or moving surfaces. Detects overheated electrical units, bearing, or pipes. Sensitive to 0.1 C.

Williamson Development Co., Inc. **3940**

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Precise quality control — the most important function of any hardness test, is one of the many reasons users depend on the King Portable! Together with the King Brinell Scope, the King Portable provides quick readings on almost any size or shape of metal in practically any location!

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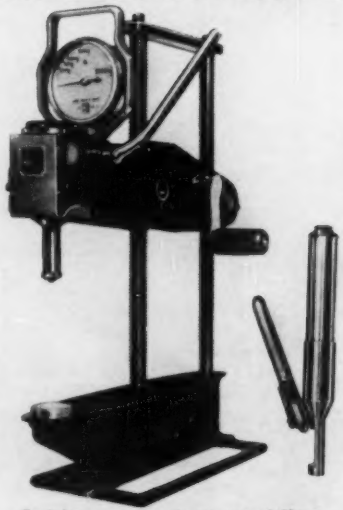

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NEW LITERATURE

Electronic Information Searching—Eight-page brochure describes American Society for Metals' new electronic system of searching technical articles, documents, and patents on metals and related subects for specific mention of any aspect of the subject.

American Society for Metals **6513**

(*Continued on p. 841*)

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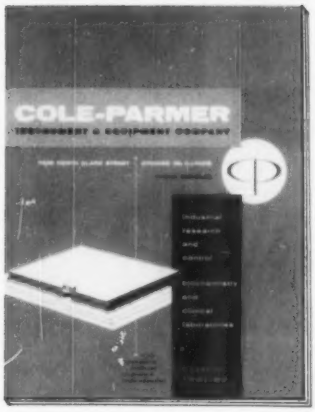

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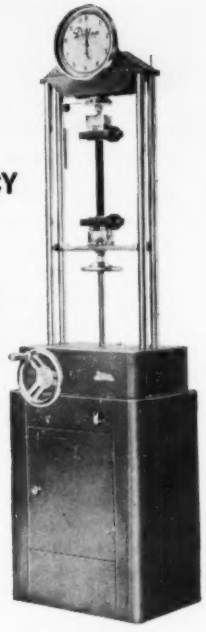

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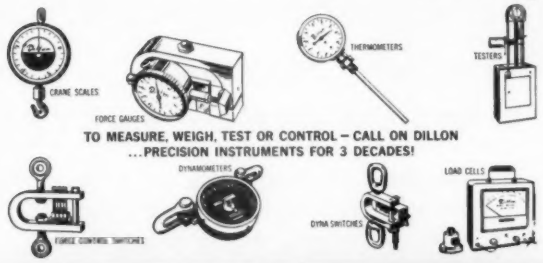

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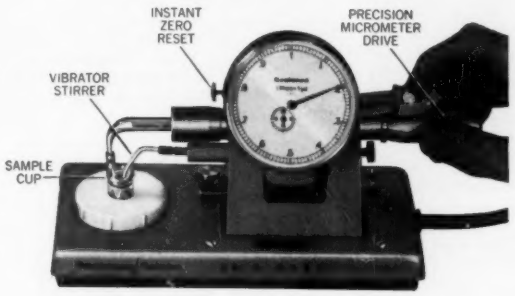

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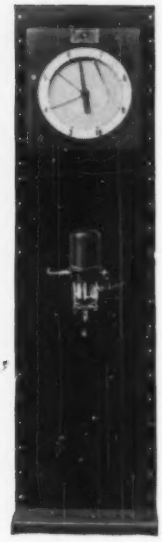

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FROM ANY MATERIAL

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TENSILGRIND precision grinds tungsten, molybdenum, and other refractory metals to RC 65 hardness. Specimens are precision ground by a series of light passes against a 7" diameter contoured grinding wheel. A solenoid controlled misting system insures cool grinding of the specimen edges.

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TENSILKUT & TENSILGRIND available as table or floor models with motors from ½ to 2½ HP.

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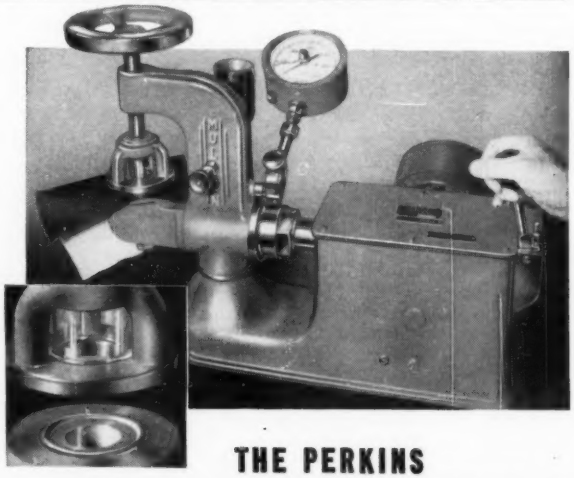

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NEW LITERATURE

(*Continued from p. 836*)

Torque Indicator—Details on a new automatic null-balance torque indicator are furnished in *Data Sheet No. 4404*. The data sheet illustrates the unit, describes features, and lists specifications and price. Rugged and dependable, the T-2A indicator is calibrated specifically for use with all B-L-H standard torque pickups. It features a large pointer and a high-visibility dial for accurate, easy reading from a distance.
Baldwin-Lima-Hamilton Corp. 6514

Metal Digest—Issue No. 3, Vol. VII, of the bimonthly external house organ, *Metal Digest*, features a variety of automatic presses for specimen mounting. This aid to laboratory automation frees the metallurgist from the time-consuming uncertain techniques of the past.
Buehler, Ltd. 6515

Catalog—*Catalog J-300* contains 1008 illustrated pages showing a complete line of over 18,000 Cenco instruments and equipment for research, educational, and industrial laboratories. A special listing has been included of Cenco equipment required for many of the tests of the American Society for Testing Materials, American Petroleum Inst., and the American Association of State Highway Officials.
Central Scientific Co. 6516

Multi-Range Meters—*Bulletin No. 06-209* discusses the features and specifications of the Model 911-912 line of a-c and d-c voltmeters and ammeters. The new meters, designed as portable instruments, are described as easily converted to panel or switchboard mounting without adapters.
Daystrom, Inc. 6517

Programmer—A 2-page, 2-color flyer describes a new one-knob controller of multiple, sequential functions ideal for test equipment.
Dynak, Inc. 6518

Microscope Accessories—New 36-page catalog describes 250 accessories for users of electron microscopes.
Ernest F. Fullam, Inc. 6519

Pressure Testers—A new 4-page catalog describing dead-weight and comparator testers contains photographs and technical data on the two general classes of testers: Type T, for use with distilled water to avoid oil contamination of pressure instruments, and Type R for testing with oil, for those applications where water is not suitable.
Mansfield & Green, Inc. 6520

Power Supply—*Catalog Sheet C-1* describes the Model HV-40 high-voltage power supply, a new RF-type unit providing continuously variable d-c output voltages in the range from 10 to 40 kv. Included is a block diagram illustrating the advanced Mikros circuitry, originally developed to meet the exacting requirements of electron microscopy, and a graph showing the unit's load characteristics.
Mikros, Inc. 6521

Instruments Catalog—A new 28-page catalog titled *Norelco X-Ray Analytical Instrumentation* contains specifications and operating data on seven key instruments for research and production control. Booklet describes electron probe microanalyzers, automatic X-ray spectrographs, 100-kv constant-potential X-ray spectrographs, portable X-ray spectrometers, standard vacuum X-ray spectrographs, X-ray diffractometers, X-ray diffraction units, and cameras.
Philips Electronic Instruments 6522

Recording Titrator—*Bulletin D* describes in detail the new Sargent recording titrator. Called Model D, it is an all-purpose automatic and potentiometric reading titrator with dual, motor-driven titration assemblies, multiple direct-reading pH and millivolt ranges, and an automatic rate sensing and adjusting system to prevent curve distortion in slow reaction systems.
E. H. Sargent & Co. 6523

Plating Analysis—Quick, accurate analysis of acid gold alloy plating solutions obtained by polarographic methods are described in 3-page paper by Karl Schumpelt and A. H. Craft. Reprints of this paper, "Polarographic Methods for the

(*Continued on p. 842*)

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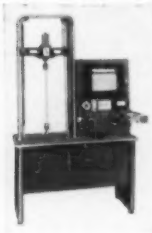

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SCOTT TESTERS

THE SURE TEST . . . SCOTT

CIRCLE 1989 ON READER SERVICE CARD

NEW LITERATURE

(*Continued from p. 841*)

Analysis of Acid Gold Alloy Plating Solutions," are available free of charge.

Sel-Rex Corp. 6524

Constant-Voltage Supply—*Product Information Sheet No. 102* describes the constant-voltage supply, an extremely stable, space-saving unit to replace dry cells and manual standardization circuitry in potentiometer and wheatstone bridge instruments. The constant-voltage supply also can provide 1.5 v dc at rated load of 1.4 ma in any other application requiring high stability and dependability.

Thermo Electric Co., Inc. 6525

Melting Point Apparatus—*Bulletin 133* describes "Uni-Melt," with glareless illumination, restricted to the scale of the thermometer, and provided with an 8-w fluorescent lamp in ventilated metal housing. The more sharply visible thermometer meniscus increases ease of reading thereby promoting greater accuracy of individual readings and decreases the time for a series of determinations.

Arthur H. Thomas Co. 6526

Testing Booklet—*Facts on Testing* is written and published periodically to inform technical people concerned with physical testing of new developments in test instruments, new testing methods, new applications for test instruments, short cuts discovered by other readers, new useful accessories for instruments, and trends in testing research and development work.

Thwing-Albert Instrument Co. 6527

Gage Coatings—A new brochure introduces the Type EC permascope for nondestructive measurement of a nonconductive coating on a nonferrous base metal such as aluminum or copper, a nonferrous coating on a nonferrous base, a nonferrous coating on a nonconductor, and conductivity of a nonferrous metal.

Twin City Testing Corp. 6528

LABORATORIES

New York Testing Laboratories, Inc., New York, N. Y.—Has added to its facility a 50-ft vessel which will be used as a marine laboratory. The purpose of the floating laboratory will be to test marine electronic items, corrosion protection devices, and de-salting processes. The items will be subjected to marine environments in order to test those conditions to which components and systems will be subjected in actual use on naval aircraft, missiles, atomic submarines, small pleasure boats, and naval vessels.

The Polymer Corp., Reading, Pa.—A newly remodeled laboratory designed for plastics product research and pilot plant development has been placed in operation. The 14,450 sq ft structure which triples the space allotted to Polymer's research, is located in the Northmont area of Reading, adjoining the company's main manufacturing plant.

MATERIALS

Castable Refractory—A new high-strength castable refractory has been developed for pneumatic gun placement with low rebound loss and minimum dusting. Placed by wet or dry gun methods, the castable produces a high-strength monolithic body with outstanding abrasion resistance and excellent resistance to thermal shock. The new gunning castable has a recommended use temperature of 2500 F.

The Babcock & Wilcox Co., New York, N. Y.

Brass—A new handbook on brass has been published which contains data on composition, specifications, properties, and other technical information on wire, rod, and strip.

H. K. Porter Co., Inc., Riverside, N. J.

OTS REPORTS

These reports, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Wood

Commercial Standard for Mat-Formed Wood Particleboard for Interior Use, *CS 236–61*, 10 cents.

Third Report on Preservative Treatment of Wood for Combat Vehicles, *PB 171 330*, 75 cents.

Bonding Preservative-Treated Veneers, *PB 171 167*, 50 cents.

Deflection Characteristics of a 20-ft-Diameter Laminated Wood Ring Subjected to Compressive Loading Along a Diameter, *PB 171 165*, 75 cents.

Effect of Lamination Thickness on Shrinkage and Swelling of White Oak Laminates, *PB 171 175*, 75 cents.

Effect of Board Thickness on Bending Radii of Ekki, *PB 171 172*, 50 cents.

The Extraction and Purification of the Wood Preservative Constituent of Osage Orange, *PB 111 458*, 75 cents.

Radioactivity and Nuclear Materials

Nuclear Safety Guide, *TID-7016*, 50 cents.

Handbook of Nuclear Safety, *DP-532*, $2.75.

Nuclear Fuels and Materials Development, *TID 11295*, $2.75.

Radioisotopes in World Industry—Abstracts of Selected Foreign Literature, *TID-6613*, $2.50.

Radiometry (V. I. Baranov's radiometry study, USSR), *AEC-tr-4432*, $4.50.

Applications of Nuclear Radiation and Radioisotopes to Textile Materials and Processes, *NCSC-2477-1*, $2.50.

(*Continued on p. 845*)

NEWS OF MEMBERS

Bernard G. Achhammer, formerly assistant chief, Organic Plastics Section, National Bureau of Standards, Washington, D. C., is now with the National Aeronautics and Space Administration, Washington, D. C.

M. M. Beckwith is now vice-president, R. O. Hull & Co., Inc., Rocky River, Ohio. He had been with The Harshaw Chemical Co., Cleveland, Ohio.

Howard G. Blake, III, previously packaging technologist, Reed Research, Inc., Washington, D. C., is now research associate, School of Packaging, Michigan State University, East Lansing, Mich.

Robert H. Bollinger, prior to becoming sales manager, Central District, Warner Co., Bellefonte, Pa., was with Georgia Kaolin Co., Elizabeth, N. J.

Nathaniel Brenner has been appointed product line manager for laboratory gas chromatography, The Perkin-Elmer Corp., Norwalk, Conn. He was manager of applications engineering.

Edward E. Brush has been advanced to executive vice-president, Soiltest, Inc., Chicago, Ill. Formerly he was sales manager.

R. L. Burke, president, Sun Shipbuilding and Dry Dock Co., Chester, Pa., retired June 30, 1961. Mr. Burke represented his company's sustaining membership in the Society.

Bill Bryant, city engineer, Jacksonville, Fla., has been appointed to the post of engineer-director, the Florida Limerock Inst.

Benson Carlin is now technical director, Carlin Associates, Fair Lawn, N. J. He had been vice-president and executive director, Circo Ultrasonic Corp., Clark, N. J.

Richard H. Carter is associated with Autonetics Div., North American Aviation, Inc., Downey, Calif., as a standards engineer.

P. P. Cioffi, a member of Committee A-6 on Magnetic Properties, has retired from Bell Telephone Laboratories, Inc., Murray Hill, N. J. He will continue as a consulting member of the committee.

About the middle of this month **Simon Collier** moved from New Rochelle, N. Y. to 10562½ Wilshire Blvd., Los Angeles, Calif., where he has taken on a part-time assignment in the field of quality control at the University of California, Los Angeles. Mr. Collier will continue his ASTM activities.

Raymond W. Fenn, Jr., formerly chief, testing and instrumentation, Metallurgical Laboratory, The Dow Metal Products Co., Midland, Mich., is now staff scientist, Metallurgy and Ceramics Dept., Lockheed Missiles and Space Div., Lockheed Aircraft Corp., Palo Alto, Calif.

Gabriel Filgueiras is president, Sidel Comercioe Industria, S. A., Rio de Janeiro, Brazil. Previously he was with the Society Importadora de Equipamentos, Ltda, Rio de Janeiro, Brazil.

William L. Glowacki, formerly assistant director of research, Eastern Gas and Fuel Associates, Boston, Mass., has been promoted to manager of a newly created Department of Technical Services.

Robert S. Goldberg, prior to becoming product chemist, General Electric Co., Insulating Materials Dept., Schenectady, N. Y., was a research fellow, Department of Chemistry, University of Massachusetts, Amherst, Mass.

Jules A. Guedalia is assistant to president, Cafritz Co., Washington, D. C. He had been vice-president, Charles H. Tompkins Co., Washington, D. C.

Marvin B. Happ, previously assistant general manager, Tang Industries, Waltham, Mass., is now vice-president and manager, Equipment Manufacturing Div., Integron, Inc., Waltham, Mass.

J. Stuart Hunter is associate professor of chemical engineering, Princeton University, Princeton, N. J. He was a statistician in the Mathematics Research Center, University of Wisconsin, Madison, Wis.

Bayard S. Johnson is with Reilly-Whiteman-Walton Co., Conshohocken, Pa., as manager of chemical sales. He had served in a similar position with Franklin Research Co., Industrial Div., Phila., Pa.

John R. Jones, Jr., formerly group leader, Plastics Div., Allied Chemical Corp., Toledo, Ohio, is now research chemist, research and development, Johns-Manville Corp., Waterville, Ohio.

Herbert S. Kalish is associated with United Nuclear Corp., New Haven, Conn., as section chief, nuclear metallurgy. Previously he was chief, Materials Section, Olin Mathieson Chemical Corp., New Haven, Conn.

C. N. Kaper, formerly manager, Fasting-Jonk N. V., Koog a/d Zaan, The Netherlands, is serving in the same capacity with Paramelt N. V., Amsterdam, The Netherlands.

Young Chun Kim, formerly a civil engineer with Daniel, Mann, Johnson & Mendenhall, Los Angeles, Calif., is now a graduate student, University of Southern California, School of Engineering, Los Angeles.

(Continued on p. 844)

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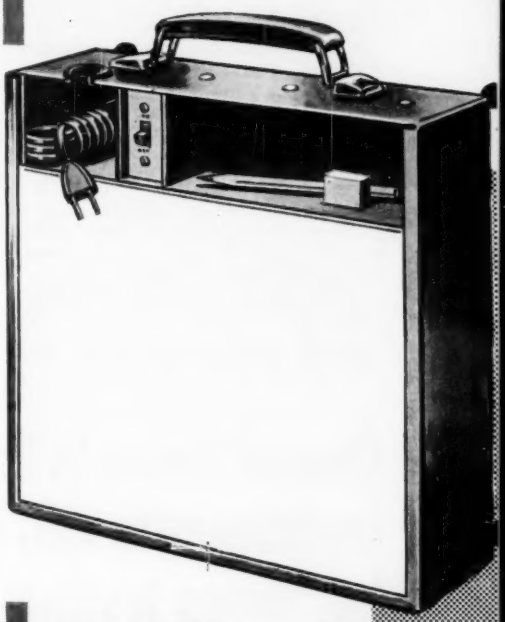

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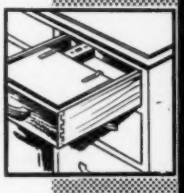

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NEWS OF MEMBERS

(*Continued from p. 843*)

Harry E. Lloyd, formerly general manager and chief engineer, Hetch Hetchy Water and Power Project and the Utilities Engineering Bureau of the City and County of San Francisco, Calif., has joined De Leuw, Cather & Company, San Francisco, Calif., as an associate.

Erwin M. Lurie is now manager, Materials Testing Laboratory, Building Industries Laboratory, Chicago, Ill. He had been materials engineer, Veterans Administration, Washington, D. C.

Charles C. Luther is a professional engineer, Luther Engineering Service, Mathis, Tex. Formerly he was quality control unit supervisor, Creole Petroleum Corp., Estado, Zulia, Venezuela.

L. C. Marshall, previously associate technical director, Microwave Power Laboratory, Varo Manufacturing Co., Garland, Texas, is acting director, Materials Research Laboratory, Graduate Research Center of the Southwest, Dallas, Tex.

Neal B. Mitchell, Jr., formerly assistant professor, Department of Architecture, Cornell University, Ithaca, N. Y., is now assistant professor, Graduate School of Design, Harvard University, Cambridge, Mass.

Gordon C. Mutch retired recently from the Research Dept., Revere Copper and Brass, Inc., Rome, N. Y. Mr. Mutch has been a personal member of the Society since 1955 and active in Committees B-2 on Non-ferrous Metals and Alloys, B-5 on Copper and Copper Alloys, B-7 on Light Metals and Alloys, and the Central New York District Council. Although now residing in Toronto, Mr. Mutch is maintaining his membership on Committee B-5 and in the Society.

Dewey H. Palmer is director, medical engineering, Becton, Dickinson & Co., Englewood Cliffs, N. J. He had been director, product development, Clay-Adams, Inc., New York, N. Y.

Pryor N. Randall is a member of the technical staff, Space Technology Laboratories, Inc., Los Angeles, Calif. Previously he was a project engineer, Engineering Research Dept., American Oil Co., Whiting, Ind.

Harold J. Read, professor of physical metallurgy, The Pennsylvania State University, University Park, Pa., received the Charles Henry Proctor Memorial Leadership Award during the Annual Convention of the American Electroplaters' Society in Boston. He earned this honor for outstanding leadership and service to AES as creator of the acclaimed "Hydrogen Embrittlement in Metal Finishing" Symposium.

James M. Rice, director, road research, Natural Rubber Bureau, Washington, D. C., has been elected president, Association of Asphalt Paving Technologists.

Harry L. Saums, Anaconda Wire and Cable Co., Magnet Wire Research and Development Laboratory, Muskegon, Mich., has received an honorary electrical engineering degree from South Dakota State College. This was the first such degree ever awarded by the school. Mr. Saums is a member of Committee D-9 on Electrical Insulating Materials.

Norman Shackman, formerly assistant director, research and development, I-T-E Circuit Breaker Co., Detroit, Mich., is now in the Engineering Dept., Electric Regulator Corp., Norwalk, Conn.

Carl H. Simon, vice-president and chief engineer, Darling Valve and Manufacturing Co., Williamsport, Pa., has been elected to the Board of Directors, American Standards Assn., for a three-year term, on the nomination of the valve and fittings industry on the Board.

Frank T. Sisco, prior to becoming a consultant in metallurgy, New York, N. Y., was director, Alloys of Iron Research, New York, N. Y.

Terry E. Steiner, formerly technical director of laboratory, Marathon Rubber Products Co., Wausau, Wis., is technical director, Marathon Plastics Corp., Wausau Wis.

Morton L. Stern, previously quality control manager, Huyck Systems Co., Huntington Station, N. Y., is now director of quality control, Telechrome Manufacturing Corp., North Port, N. Y.

Harold R. Terhune, manager of standards, International Telephone and Telegraph Corp. Laboratories, Nutley, N. J., became president of the Standards Engineers Society at its Annual Meeting in Chicago.

Willis F. Thompson, vice-president, Westcott & Mapes, Inc., New Haven, Conn., was elected an Honorary Member of The American Society of Mechanical Engineers.

Charles V. Vance is consulting physicist, Advance Enterprises, Waukegan, Ill. He had been physicist, Research & Development Laboratories, Portland Cement Assn., Skokie, Ill.

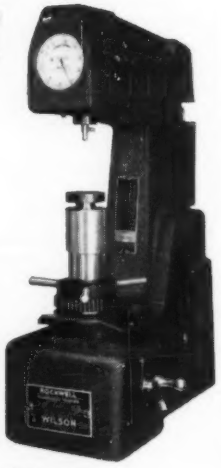
Wolfe S. van Eyken, formerly research chemist, Coatings Research Group, Inc., Bethesda, Md., is research supervisor, H. B. Fuller Co., Cincinnati, Ohio.

Harold A. Vicker, vice-president and chief engineer, Pennsylvania Gas and Water Co., Wilkes Barre, Pa., was recently elected a director of the utility.

E. Mark Wolf is administrative engineer, Engineering Dept., Rome Cable, Div. of Aluminum Company of America, Rome, N. Y. Formerly he was technical director, Rea Magnet Wire Co., Fort Wayne, Ind.

Joseph L. Zuckerman has joined the American Doll & Toy Corp., Brooklyn, N. Y., as director of Polymers Dept. Formerly he was research chemist, Disogrin Industries, Mt. Vernon, N. Y.

One of these Wilson "Rockwell" instruments will do your hardness testing job



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FOR FURTHER INFORMATION CIRCLE 1291 ON READER SERVICE CARD

DEATHS

Louis Anderson, Easton, Pa. (recently). Before his retirement, Mr. Anderson was chemical engineer, chief chemist, and director of research, Alpha Portland Cement Co., Easton, Pa. A member of the Society since 1913, Mr. Anderson served as a member of the Board of Directors from 1925 to 1927 and was an active member of Committees C-1 on Cement, C-12 on Mortars for Unit Masonry, and several subcommittees of E-1 on Methods of Testing. Committee C-1 elected Mr. Anderson to Honorary Membership in the committee in recognition of his outstanding contributions to the work of the committee.

Ernest S. Brown, general manager, Product Development and Process Engineering Depts., Caltex Service Co., New York, N. Y. (June 11, 1961). Mr. Brown had been a member of the Society since 1952 and was a member of Committee D-2 on Petroleum Products and Lubricants.

Jerome G. Harrison, head, Specifications Dept., The Ballinger Co., Philadelphia, Pa. (August 19, 1961). Mr. Harrison joined the Society in 1953.

Albert S. Orr, assistant manager, Technical Div., Gulf Oil Corp., Pittsburgh, Pa. (August 13, 1961). He was stricken while vacationing at Long Beach, N. J. Mr. Orr was a member of Committee D-2 on Petroleum Products and Lubricants and of the Pittsburgh District Council.

Howard S. Ponzer, vice-president, Giant Portland Cement Co., Philadelphia, Pa. (August 21, 1961). Mr. Ponzer represented his company's sustaining membership in the Society.

Edison Powers, section head, Armstrong Cork Co., Research and Development Center, Lancaster, Pa. (August 12, 1961). Mr. Powers was an active member of Committee D-11 on Rubber and Rubber-Like Materials.

OTS REPORTS

(*Continued from p. 842*)

Miscellaneous

Adhesive Bonding of Metals for Advanced Ordnance Applications, *PB 161 863*, 75 cents.

Handbook of Fibrous Materials, *PB 171 494*, $6.

Storage of Ethylene Glycol with Various Inhibitors, *PB 171 537*, 50 cents.

Infrared, Part I (General Research, Equipment, and Materials), *SB-466*, 10 cents.

Infrared, Part II (Infrared Spectroscopy), Bibliographies, *SB-467*, 10 cents.

Soaps, Detergents, Cleaning Agents (Supplement to CTR-333), *SB-468*, 10 cents.

(*Continued on p. 846*)

Engineering Index Suffers Growing Pains

THE RISING flood of technical literature, which has brought in its wake a spate of new indexing and abstracting services, is creating problems for one of the oldest of them all—the *Engineering Index*.

Established in 1885, the *Engineering Index* employs a staff of qualified editors who review, abstract, and index more than 1500 periodicals, society transactions, and bulletins and reports of government bureaus, schools, and research organizations. The literature abstracted originates in 44 countries and is published in 23 languages.

Plans were recently made for a 5000-per-year increase in the number of abstracts produced, in an effort to keep pace with the burgeoning growth of the literature. The output proposed for 1961 was 36,000 abstracts, but this figure was exceeded in 1960. This unprecedented growth, together with rising costs of printing, are causing anxious moments for the managers of the *Index* as they lay plans for the future growth which must occur if the *Index* is to continue to play its historically strategic role in keeping engineers and scientists informed.

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CIRCLE 1293 ON READER SERVICE CARD

OTS REPORTS

(*Continued from p. 845*)

Ceramics

The Influence of High Pressures and High Temperatures on Transformations and Coordination in Crystalline and Vitreous Ceramic Materials, *PB 171 595*, $1.25.

Ceramic Tile for Floors and Walls, Simplified Practice Recommendation *R61-61*, 10 cents.

Materials for High-Temperature Nuclear Engineering Applications, *ORO-325*, $2.

Uranium Glasses, III: Uranium Phosphate Glasses, *IS 267*, 50 cents.

Synthesis and Purification of Dielectric Materials, *PB 171 364*, $2.

Polymers

Improved Vinylic Fillers for the Reinforcement of GR-S Type Elastomers *PB 171 579*, $1.25.

Eighth Materials Review. A Lyem, Experimental Engineering Division, U. S. Army Chemical Research and Development Laboratories, *PB 171 612*, $2.25.

Metals

Metallurgy in the Navy, *PB 151 110*, $2.50.

High-Pressure Research in Metals and Ceramics, *PB 171 025*, $2.

Literature Survey on Research and Development on High-Pressure Technology, *PB 161 887*, $1.50.

Zirconium, Zircaloy, and Hafnium—Safe Practice Guide for Shipping, Storing, Handling, Processing, and Scrap Disposal, *WAPD-TM-17*, 75 cents.

A Comparison of the Brittle Behavior of Metallic and Nonmetallic Materials, *PB 171 626*, 50 cents.

Review of Recent Developments in the Technology of Tungsten, *PB 171 627*, 50 cents.

Review of Recent Developments in Metal Joining, *PB 171 628*, 50 cents.

Development of Randomly Oriented Wrought Beryllium Sheet, *AD 258 241*, $2.50.

Development of Optimum Methods for the Primary Working of Refractory Metals, *AD 257 865*, $3.

The Emittance of Titanium and Titanium Alloys, *PB 161 241*, 50 cents.

A Review of Recent Developments in Titanium and Titanium-Alloy Technology, *PB 161 243*, 50 cents.

Zinc Coatings for Protection of Columbium from Oxidation at Elevated Temperatures, *PB 161 238*, 50 cents.

Strengthening Mechanisms in Nickel-Base High-Temperature Alloys, *PB 161 245*, 50 cents.

A Study on Controlling High-Temperature Oxidation of Vanadium-Base Alloys, *AD 258 378*, $2.25.

Comparison of Shear Strength Values Obtained from Three Types of Shear Tests—7075-T6 Aluminum, *PB 161 989*, 50 cents.

Correlation of Toughness Between H-Plate and Charpy Impact Tests, *PB 151 850*, $1.

(*Continued on p. 851*)

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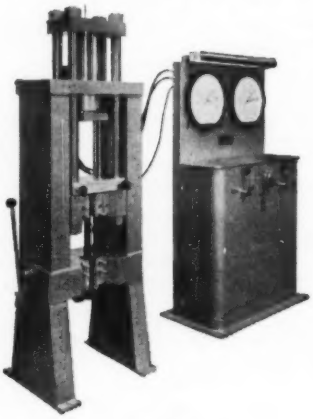

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CIRCLE 1294 ON READER SERVICE CARD

NEW MEMBERS

The following 75 members were elected from August 8 to September 8, 1961 making the total membership 10,728 . . . Welcome to ASTM. Names are arranged alphabetically, company members first then individuals. Your ASTM Year Book shows the areas covered by the respective Districts.

Central Plains District

Brink, John E., partner, Brink & Dunwoody, Iola, Kans.
Mitchell, Ralph M., principal architect, Burns & McDonnell Engineering Co., Kansas City, Mo.
Rearick, John S., vice-president and manager of engineering, The C. W. Nofsinger Co., Kansas City, Mo.
Voorhies, G. H., Benson Manufacturing Co., Architectural Div., Kansas City, Mo.

Chicago District

Brandvold, William W., section leader, Research Laboratories, Universal Atlas Cement Div., United States Steel Corp., Buffington Station, Gary, Ind.
DeLazaro, David J., chief metallurgist, Kropp Forge Co., Chicago, Ill.
Harvey, Martin Don, plant metallurgist Wisconsin Wire Works, Appleton, Wis.
LaKaff, E. P., Ingersoll Products Div., Borg-Warner Corp., Chicago, Ill.
Oetzel, Leon I., chief control chemist, Milprint, Inc., Milwaukee, Wis.
Talman, Robert, supervisor, Construction Group, The Quaker Oats Co., Chicago, Ill.

* [A] denotes Associate Member.

Cleveland District

Colonial Woolen Mills Co., The, Frank Tolka, chemist, Cleveland, Ohio.
Schroeder, E. G., The Electric Products Co. Cleveland, Ohio.

Detroit District

Pontius, D. W., manager, Chemical and Metallurgical Dept., Transmission and Chassis Div., Ford Motor Co., Livonia, Mich.
Thomas, Robert W., development engineer, Bulldog Electric Products Div., I-T-E Circuit Breaker Co., Detroit, Mich.

Mississippi Valley District

Hertz, Joseph C., quality control manager, Olin Mathieson Chemical Corp., East Alton, Ill.

New England District

Allman, William L., chief engineer, Mobil Oil Co., Boston, Mass.
Fountain, Laurence R., president, Fountain Plating Co., Chicopee Falls, Mass.

New York District

Geotechnics and Resources, Inc., D. R. Lueder, president, White Plains, N. Y.
Ames, Bernard N., president, Columbian Bronze Corp., Freeport, L. I., N. Y.
Bender, Donald E., section chief, Testing Laboratories, Western Electric, Co., Inc., Supplies Inspection Organization, New York, N. Y.
Bitko, Sheldon, chief engineer, Zell Products Corp., Norwalk, Conn.
Ellentuch, Leonard, quality control manager, Radiation Materials, Inc., Long Island City, N. Y. [A]*
Kononenko, O. K., president, Herstein Laboratories, Inc., New York, N. Y.
Langworthy, Merton L., manager, Product Development Dept., Caltex Service Co., New York, N. Y.
Martin, August, Jr., secretary-treasurer, Mineral Mining Co., Kershaw, S. C. (At Mineola, L. I., N. Y.)
Molesworth, Gordon R., president, Molesworth Associates, New York, N. Y.
Palmer, William R., editor, *The National Cleaner*, New York, N. Y.
Spirer, Lawrence, Sonneborn Associates Petroleum Corp., New York, N. Y.

Northern California District

Fondiller, Harry, president, Royco Instruments, Inc., Palo Alto, Calif.
Lawford, Victor N., project engineer, Barton Instrument Corp., Monterey Park, Calif.

Ohio Valley District

Hamilton, City of, O. Elmore Martin, city engineer, Municipal Bldg., Hamilton, Ohio
Hobart Brothers Technical School, Howard B. Cary, director, Troy, Ohio.

Philadelphia District

Buchanan, Charles E., Jr., research assistant, Penn-Dixie Cement Corp., Nazareth, Pa. [A]
Jameson, W. H., chief engineer, fabricated steel construction, Bethlehem Steel Co., Inc., Bethlehem, Pa.

(*Continued on p. 849*)

THWING-ALBERT
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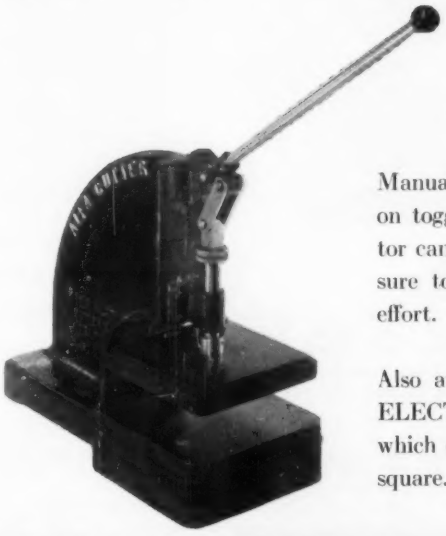

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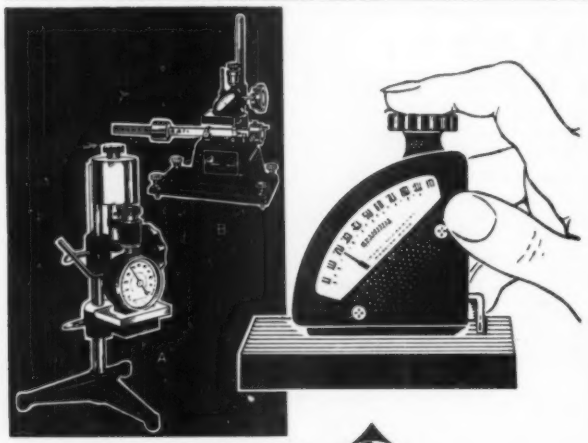

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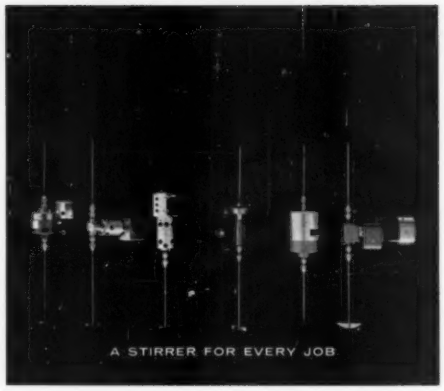

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CIRCLE 1299 ON READER SERVICE CARD

NEW MEMBERS

(*Continued from p. 847*)

Tyson, Samuel E., metallurgist, stainless steels, The Carpenter Steel Co., Reading Pa.

Pittsburgh District

Fasoli, Carlo, resident representative, Ercole Marelli, Milan, Italy (At Westinghouse Electric Corp., East Pittsburgh, Pa.)

Webb, Ralph D., manager, structural, plate and high strength steels metallurgy, U. S. Steel Corp., Pittsburgh, Pa.

Rocky Mountain District

Butler, Cecil, senior engineer, Sverdrup & Parcel and Associates, Inc., St. Louis, Mo.

Southeast District

Truss Plate Inst., Charles B. McAdam, secretary, Miami, Fla.

Behrends, Robert A., director of processing research, Fiber Quality Control and Research Dept., Deering Milliken Service Corp., Spartansburg, S. C.

South Carolina Department of Agriculture, Ralph Magoffin, chief chemist, Columbia, S. C.

White, John M., Jr., process engineering supervisor, Sperry Electronic Tube Div. Sperry Rand Corp., Gainesville, Fla.

Southern California District

Anderson, Vincent W., Engineering Div. San Fernando Valley State College, Northridge, Calif.

Fee, John R., assistant chief engineer, James M. Montgomery, Consulting Engineers, Inc., Pasadena, Calif.

Freeze, George, supervisor, Quality Control Laboratory, Rohr Aircraft Corp., Riverside, Calif.

Matlock, Robert W., vice-president, engineering-sales, Summit Industries, Inc., Gardena, Calif.

Wyman, Oliver J., general manager, Ferro-Spec Laboratories, Inc., Los Angeles, Calif.

Southwest Distrct

Byers, William G., assistant engineer, Atchison, Topeka & Santa Fe Railway Co., Amarillo, Tex.

Lipps, John G., Jr., owner-manager, Pan American Laboratories, Brownsville, Tex.

Morris, Richard E., Jr., assistant superintendent, operations, Dallas City Water Works, Dallas, Tex.

Rose, William B., chief of radiation effects research, Convair, Division of General Dynamics Corp., Fort Worth, Tex.

Tucker, Donald D., engineering assistant, Texas Highway Dept., Denton, Tex. [A]

Washington, D. C. District

Gardner, E. D., director, experimental engineering, Product Development Div., Reynolds Metals Co., Richmond, Va.

Kinter, Earl B., chief, Physico-Chemical Section, Bureau of Public Roads, Washington, D. C.

Meyerson, Melvin R., metallurgist, National Bureau of Standards, Washington, D. C.

Muse, Robert T., physicist, Quartermaster Research and Engineering Field Evaluation Agency, Fort Lee, Va.

Ravenhorst, Henry L., associate professor of engineering, Washington & Lee University, Lexington, Va.

Rumke, Richard William, staff engineer, National Academy of Sciences–National Research Council, Committee on Ship Steel, Washington, D. C.

Western New York–Ontario District

Kelly, John, group leader, Wood Finishes Group, Paint Research Laboratory, Paints Div., Canadian Industries, Ltd., Toronto, Ont., Canada.

Theophilos, Nicholas P., engineer, Cryogenic Vessel Design, Linde Co., Division of Union Carbide Corp., Tonawanda, N. Y. [A]

Outside Established Districts

Beach, Winfield G., Jr., materials engineer, Arctic Alaska Testing Laboratories, Fairbanks, Alaska. [A]

Johnson, Lawrence B., materials technician, Arctic Alaska Testing Laboratories, Anchorage, Alaska.

Marsh, Jack A., civil engineer, Pacific Architects and Engineers, Inc., c/o senior engineer advisor, K.M.A.G., APO 18, San Francisco, Calif.

Foreign

New Zealand Forest Products, Ltd., A. W. Mackney, chief chemist and general manager, Auckland, New Zealand.

Quebec Cartier Mining Co., R. S. Patton, assistant director, engineering and research, Port Cartier, P. Q., Canada.

Beissel, Frank Eric, chief metallurgist, Turner Manufacturing Co., Pty., Ltd., Lilydale, Victoria, Australia.

Bhusari, N. V., assistant resident engineer, Beauchamin-Beaton-Lapointe, Montreal, P. Q., Canada.

Chughtai, Anwar Baig, chemical assistant, Custom House, Karachi, West Pakistan. [A]

Eckford, Edward W., materials engineer, Tipton & Kalmbach, Inc., Lahore, West Pakistan.

Hale, Edwin C., The Arboriet Co., Ltd., Ville La Salle, Montreal, P. Q., Canada

Indian Institute of Petroleum, Library, New Delhi, India.

McGuinness, T., manager, Technical Services Dept., Regent Oil Co., Ltd. London, England.

Murfitt, R. F., chief engineer, Consolidated Concrete, Ltd., Calgary, Alta., Canada.

Universidad de Buenos Aires, Faculatad de Ingenieria, Departamento Vias de Comunicacion, Buenos Aires, Argentina.

Wijnmalen, E., Algemen Kunstzijde Unie N. V., Arnhem, The Netherlands.

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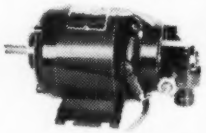

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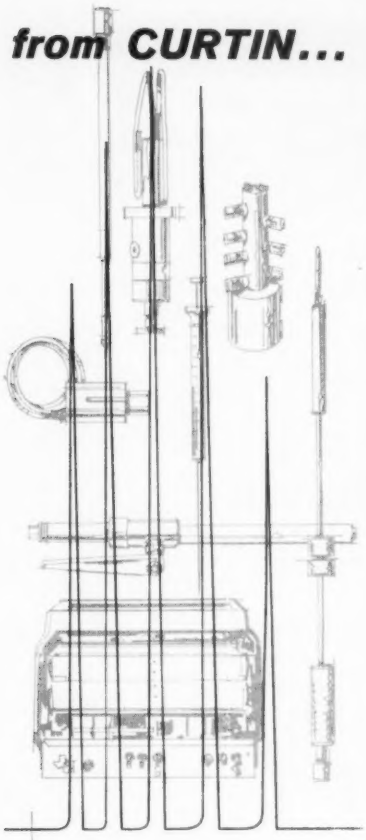

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CIRCLE 1305 ON READER SERVICE CARD

CALENDAR

Oct. 30–Nov. 1—**American Oil Chemists' Society,** Fall meeting, Pick-Congress Hotel, Chicago, Ill.

Oct. 31–Nov. 4—**Federation of Societies for Paint Technology,** Annual Meeting and Paint Industries' Show, Shoreham Hotel, Washington, D. C.

Nov. 1–3—**Society for Experimental Stress Analysis,** International Congress on Experimental Mechanics, Hotel New Yorker, New York, N. Y.

Nov. 1–3—**Mellon Institute,** 19th Annual Pittsburgh Diffraction Conference, Mellon Institute, 4400 Fifth Avenue, Pittsburgh, Pa.

Nov. 1–3—**American Concrete Institute,** 14th Regional Meeting, Dinkler-Tutwiler Hotel, Birmingham, Ala.

Nov. 6–10—**Atomic Industrial Forum and American Nuclear Society** Annual Conference, AtomFair Atomic Exhibit, and Ninth Hot Laboratories and Equipment Conference, Conrad Hilton Hotel, Chicago, Ill.

Nov. 12–15—**Air-Conditioning and Refrigeration Institute,** Annual Meeting, The Homestead, Hot Springs, Va.

Nov. 13–15—**Society of Petroleum Engineers of American Institute of Mining, Metallurgical and Petroleum Engineers,** and **American Petroleum Institute,** Annual Meeting, Chicago, Ill.

Nov. 13–17—**National Electrical Manufacturers Association,** Annual Meeting, Traymore Hotel, Atlantic City, N. J.

Nov. 15–18—**The Society of Naval Architects and Marine Engineers,** Annual Meeting, The Waldorf Astoria Hotel, New York, N. Y.

Nov. 26–Dec. 1—**American Society of Mechanical Engineers,** Annual Meeting Statler-Hilton Hotel, New York, N. Y.

Dec. 3–7—**American Institute of Chemical Engineers,** Annual Meeting, Commodore Hotel, New York, N. Y.

Dec. 13–15—**American Society of Agricultural Engineers,** Winter Meeting, The Palmer House, Chicago, Ill.

Dec. 26–31—**American Association for the Advancement of Science,** Annual National Meeting, Denver Hilton, Brown Palace, Cosmopolitan, and Shirley Savoy Hotels, Denver, Colo.

Dec. 27–30—**American Statistical Association and Institute of Mathematical Statistics,** 121st Annual Meeting, Roosevelt Hotel, New York, N. Y.

OTS REPORTS

(Continued from p. 846)

Survey of Materials for High-Temperature Bearing and Sliding Applications, *AD 257 408*, 50 cents.

Stress-Corrosion Cracking—A Nontechnical Introduction to the Problem, *PB 151 103*, 75 cents.

Development of the Extrusion Method for the Production of Wide-Profile Extrusions—Volume 1, *PB 171 568-1*, $3.

Development of the Extrusion Method for the Production of Wide-Profile Extrusions—Volume 2, *PB 171 568-2*, $3.

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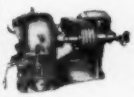

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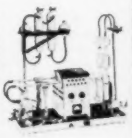

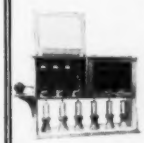

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GOVERNMENT STANDARDS CHANGES

THE FEDERAL Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for Procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The following items appeared in Supplement 5 for July, 1961.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity
Glossary of Fabric Imperfections	Rev.	Fed. Std. No. 4	8305	ARMY-QMC
Metals, Test Methods	New	Fed. Std. 151a	...	ARMY-ORD
Aluminum Alloy Permanent and Semi-Permanent Mold Castings	Rev.	QQ-A-596b	9530	NAVY-SHIPS
Brazing Alloy, Copper, Copper-Zinc, and Copper Phosphorus	Am. 1	QQ-B-650	...	NAVY-SHIPS
Cable and Wire, Power, Electrical, Non-metallic-Sheathed	Rev.	J-C-94a	6145	GSA-FSS
Copper Rods and Shapes and Flat Products with Finished Edges (Flat Wire and Strips)	...	QQ-C-502b	9540	NAVY-SHIPS
Cord, Flexible, and Wire Fixture, Electrical (0 to 600 v Service)	Rev.	J-C-86a	6145	GSA-FSS
Isopropyl Alcohol, Technical	Rev.	TT-I-735a	6810P	NAVY-WEP
Nickel-Copper Alloy and Nickel-Copper Silicon Alloy Castings	Am. 1	QQ-N-288	95	NAVY-SHIPS
Pipe, Drain and Sewer, Plastic	Am. 1	WW-P-00380	5630	GSA-FSS
Pipe, Red Brass, 85 Per Cent, Seamless, Standard Pipe Size, Regular and Extra Strong	Rev.	WW-P-351	4710	USAF
Primer, Pressure, Internal Combustion Engine (Cold Starting Aid) and Primer Cartridges	Rev.	F-P-666d	2d05	GSA-FSS
Scouring Powder	Am. 2	P-S-311a	7930	GSA-FSS
Sealing Compound, Rubber Base, Two Components (for Chalking Sealing and Glazing)	New	TT-S-227a TT-S-00227	8030	COM-NBS
Sodium Polyphosphate, Technical Water Treatment	Rev.	O-S-635c	6810	ARMY-CMLC
Sponge, Natural	Rev.	C-S-631c 00631d	7920	INT-F&WS
Tubes, Condenser and Ferrule Stock, Admiralty Metal	Rev.	WW-T-756c	4710	NAVY-SHIPS

SPECIFICATIONS AND STANDARDS APPROVED FOR PRINTING

Title	Type of Action	Symbol or Number
Aluminum Alloy Bar, Rod, and Wire, Rolled, Drawn, or Cold-Finished, 2017	Rev.	QQ-A-351e
Aluminum Bronze Bars, Rods, Shapes, Drawn Strips, and Forgings	Canc.	QQ-A-630
Amylacetate (for Use in Organic Coatings)	Rev.	TT-A-511b
Bag, Paper, Waxed (Sandwich)	New	UU-B-50a
Bronze, Aluminum, Rod, Flat Products, with Finished Edges (Flat Wire, Strip, and Bar), Shapes and Forgings	New	QQ-B-679
Burners, Bunsen, Laboratory	Canc.	GG-B-817
Burner, Gas, Laboratory	New	NNN-B-795
Chemicals, Liquid, Packaging and Packing of	New	PPP-C-300
Chlorination Kit, Water Purification (for Treatment of Drinking Water)	Rev.	O-C-289b
Cork Sheets (Gaskets, Sheets, and Strips)	Rev.	HH-C-576b
Copper, Flat Products with Slit and Edge-Rolled, Sheared, Sawed, or Machined Edges, (Plate, Bar, Sheet, and Strip)	Rev.	QQ-C-576b
Creosote, Coal Tar, Technical	New	TT-C-645a
Drums, Shipping, Steel, ICC-6A and ICC-6B (for Phosphorus, White or Yellow, Dry or in Water)	Rev.	PPP-D-736a
Drums, Steel, Type 6A (for Phosphorus, White or Yellow)	Canc.	RR-D-736
Floor Plate, Steel, Rolled	Rev.	QQ-F-461b
Form, Concrete Paving, Steel	Rev.	RR-F-576a
Heels: Rubber	Rev.	ZZ-H-141b
Insulation Board, Thermal	New	HH-I-524
Leather, Cattlehide, Vegetable-Tanned, and Soles, Leather	Am. 2	KK-L-165
Neat's-Foot Oil	Rev.	C-N-200a
Paint, Exterior, Black, Ready-Mixed	Rev.	TT-P-61d
Paints, Varnish, Lacquer, and Related Materials, Packaging, Packing, and Marking of	Am. 1	TT-P-143a
Paper, Newsprint	New	UU-P-405a
Pigment, Titanium Dioxide (for Protective Coatings)	New	TT-P-442
Pipe, Steel, (Seamless and Welded, Black and Zinc-Coated (Galvanized)	Rev.	WW-P-404c
Plate, Surface, (Granite)	Rev.	GGG-P-463b
Plastic Film (Polyethylene Thin Gage)	New	L-P-378a
Printing and Stationary Paper, Packaging and Packing for Domestic and Overseas Shipment	Am. 2	...
Rope, Jute	Rev.	T-R-582a
Soap, Toilet (Floating White)	Am. 2	P-S-616d
Sodium Phosphate, Dibasic, Anhydrous, Technical	Rev.	O-S-639a
Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose)	Rev.	QQ-S-624b
Titanium Dioxide, Dry (Paint-Pigment)	Canc.	TT-T-425a
Toluene, Technical	Rev.	TT-T-548c
Wood Preservative, Ammoniacal Copper Arsenite Mixture	Rev.	TT-W-549c
Wood Preservative, Chromated Zinc Arsenate Mixture	Rev.	TT-W-538b
Wood Preservative, Coal-Tar Creosote	Canc.	TT-W-556b
Wood Preservative, Copperized Chromated Zinc Chloride Mixture	Rev.	TT-W-562b
Wood Preservative, Fluor Chrome Arsenate Phenol Mixture	New	TT-W-535a
Wood Preservative, Osmosar (Osmosalts)	Canc.	TT-W-569
Wood Preservative, Treating Practices	Rev.	TT-W-571g
Wood Preservative, Wolman-Salt (Tanalith)	Canc.	TT-W-573

PROMULGATIONS

Title	Type of Action	Symbol or Number
Rubber, Sampling and Testing	Chg. Not. 1	Fed. Test Method Std. 601
Soap and Soap Products (Including Synthetic Detergents), Sampling and Testing	...	Fed. Test Method Std. 536
Cable, Telephone (W-106B)	New	J-C-96
Cardboard and Railroad Board (Manila and Wood)	Am. 1	UU-C-201e
Chemicals, Dry and Paste, Packaging and Packing of	New	PPP-C-301
Cleaning Compound, Toilet Bowl (Superseding O-C-00426e(GSA-FSS) and O-C-426d)	Rev.	P-C-447
Cloth, Cotton, Flannel, Canton (Superseding CCC-F-451)	Rev.	CCC-C-458
Fiberboard, Sheet Stock and Cut Shapes (Superseding PPP-F-00320(QMC)	Rev.	PPP-F-320a
Hydraulic Fluid, Nonpetroleum Base, Automotive	Rev.	VV-H-910a
Insulation Block, Pipe Covering, and Cement, Thermal, Calcium Silicate (for Temperatures up to 1200 F)	Am. 2	HH-I-523a
Laces, Footwear, Spun Nylon	Am. 1	V-L-61c
Lacquer, Rubbing, Clear, (for Wood Furniture)	Rev.	TT-L-57b
Molding Plastic, Cellulose Acetate	Am. 3	L-M-505
Optical Flats	Am. 1	GG-O-635
Oxalic Acid, Dihydrate, Technical (Superseding O-A-91)	Rev.	O-O-690
Soap, Grit (Hand, Paste, and Powder)	Am. 2	P-S-577
Sodium Orthosilicate, Technical, Superseding P-S-00651b (Army-CMLC) and P-S-651a	Rev.	P-S-651c
Tape, Pressure-Sensitive, Double-Coated (Superseding UU-T-0091b and UU-T-91a)	Rev.	UU-T-91c
Wood Preservative, Acid Copper Chromate Mixture (Superseding TT-W-00546b (AGR-FS) and TT-W-546a)	Rev.	TT-W-546c
Wood Preservative, Chromated Copper Arsenate Mixture (Superseding TT-W-00550a (AGR-FS and TT-W-548a)	Rev.	TT-W-550b
Wood Preservative, Chromated Zinc Chloride Mixture (Superseding TT-W-00551c (AGR-FS) and TT-W-551b)	...	...

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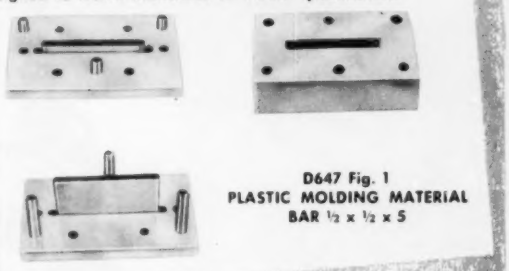

D647 Fig. 1
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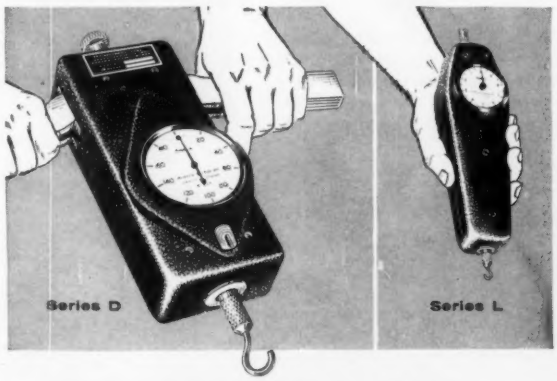

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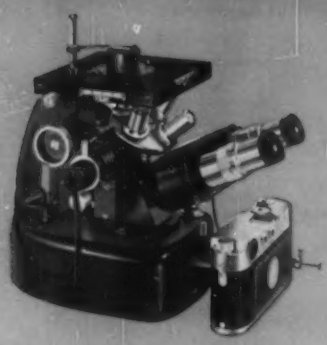

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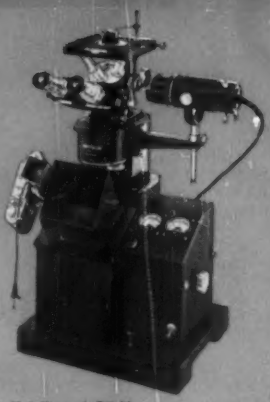

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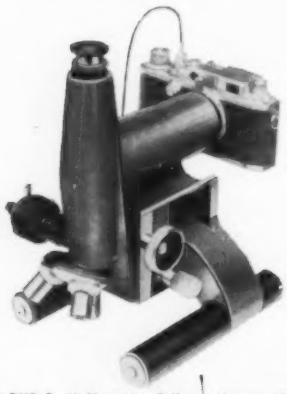

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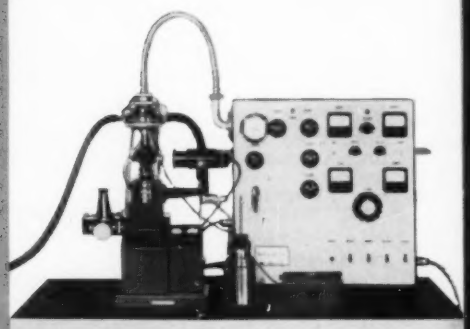

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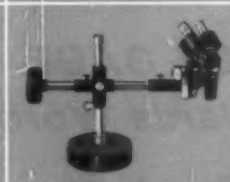

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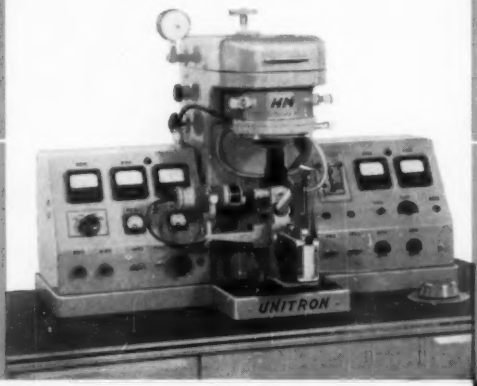

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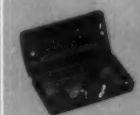

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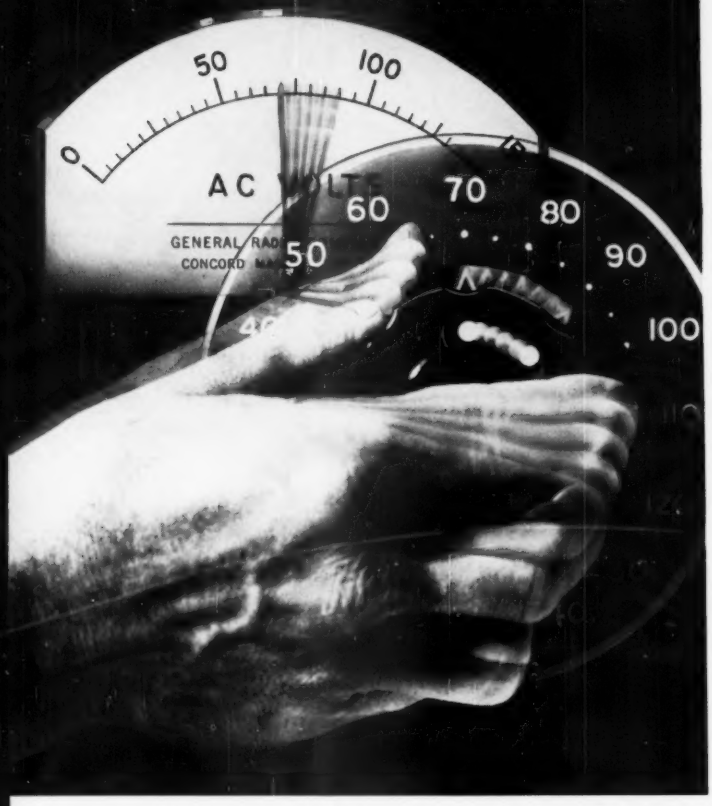

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With DURATRAK† Contact Surface

. . . the most useful device yet developed for the control of a-c voltage — heat — light — power — speed.

High Efficiency — low-loss VARIAC autotransformers do not dissipate large amounts of power as do resistive controls.

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FOR A COMPLETE LISTING, WRITE FOR MORE INFORMATION

Model	Input Voltage	Load Rating (KVA)	Output Voltage	Rated Current (Amps)	Maximum Current (Amps)*	Price
W2 UNCASED	120	0.37	0-140	2.4	3.1	$15.00
W2M CASED	120	0.31	0-140	2.0	2.6	21.00
W2MT3 PORTABLE	120	0.28	0-140	2.0	2.4	28.00
W5 UNCASED	120	0.94	0-140	6.0	7.8	18.00
W5M CASED	120	0.78	0-140	5.0	6.5	24.00
W5MT3 PORTABLE	120	0.73	0-140	5.0	6.0	32.50
W10 UNCASED	120	1.56	0-140	10.0	13.0	31.00
W10M CASED	120	1.56	0-140	10.0	13.0	44.00
W10MT3 PORTABLE	120	1.56	0-140	10.0	13.0	53.50
W20 UNCASED	120	3.12	0-140	20.0	26.0	48.00
W20M CASED	120	3.12	0-140	20.0	26.0	61.00
W20MT3 PORTABLE	120	3.12	0-140	20.0	26.0	90.00
W30 UNCASED	120	4.32	0-140	30.0	36.0	75.00
W30M CASED	120	3.84	0-140	28.0	32.0	97.00
W50 UNCASED	120	6.0	0-140	50	50	120.00
W50M CASED	120	5.4	0-140	40	45	145.00

*For "O to Line Voltage" Connection.

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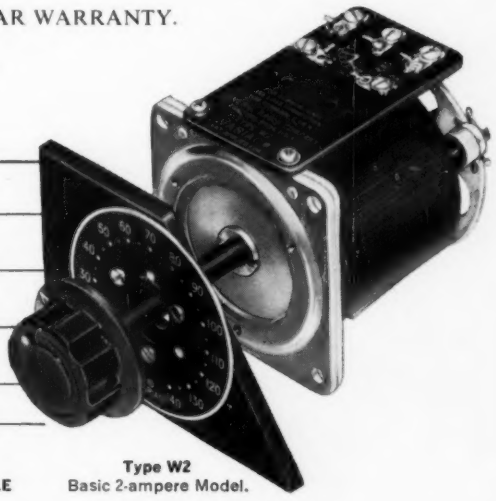

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Basic 2-ampere Model.

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